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ABSTRACT

The conference was centered on the theme, The Impact of Testing on the Educational Process. The morning session was devoted to the broader thematic aspects and included the following papers: What Testing Does to Teachers and Students, by Ralph W. Tyler: Some Lessons for High School Physics, by Walter C. Michels: and Education 1975, by Paul Woodring. The afternoon session centered on specific new teaching and testing devices and included papers entitled: Intrinsically Programmed Teaching Devices, by Norman A. Crowder: Teaching Machines: an Application of Principles from the Laboratory, by James G. Holland: and Self-Correcting Homework in English, by Paul B. Diederich. The luncheon address was delivered by James B. Conant. (MH)

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Invitational Conference on Testing Problems

October 31, 1959

Hotel Roosevelt, New York City

DOROTHY ADKINS WOOD, Chairman



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Foreword

The 1959 Invitational Conference on Testing Problems, in the tradition of this annual event, provided the many individuals of diverse interests who attend these meetings an opportunity to consider a set of varied ideas and developments in the fields of education and measurement.

The basic theme of the program was "The Impact of Testing on the Educational Process." The papers delivered by the principal speakers ranged from broad considerations of this subject to reports on specific projects and research studies related to testing in education. All of them contributed new ideas and insights useful to the educator, the measurement specialist, the psychologist, and the citizen with a general interest in education.

To the Conference Chairman, Dr. Dorothy Adkins Wood of the University of North Carolina, I want to express our appreciation for producing such a valuable program. We are equally indebted to the principal speakers who shared their thoughts and research findings with those at the Conference. We are pleased to publish their papers in this *Proceedings*, so that others interested in these questions may have access to the stimulating ideas presented at the 1959 Invitational Conference.

HENRY CHAUNCEY
President



Early arrivals at 1959 Invitational Conference receive name cards.

Dr. Walter C. Michels (center) enjoys conversation at Coffee Hour.



Preface

For the 1959 Invitational Conference on Testing Problems, the most timely and pertinent theme around which to build the program seemed to be "The Impact of Testing on the Educational Process." Certainly, we thought, we could presume an interest in both testing and education on the part of those who would attend. Equally certain was the fact that the growing use of tests in education was attracting widespread interest and debate, both in educational circles and among the public at large.

With what we hoped was a "surefire" theme, we set out to find the best persons available to present different views and reports on the subject. Our success in that search accounted for the extremely interesting papers presented at the 1959 Invitational Conference. The more than 500 persons attending, all with diverse special interests, could find something new and stimulating in every presentation.

The morning session, devoted to the broader aspects of the impact on testing in education, brought together on one platform Ralph W. Tyler, Director of the Center for Advanced Study in the Behavioral Sciences; Walter C. Michels, Professor of Physics at Bryn Mawr College; and Paul Woodring, Educational Adviser to the Ford Foundation.

At the afternoon session, which focused on specific new teaching and testing devices, we heard from Norman A. Crowder, Director of the Training Systems Department at Western Design, a division of U. S. Industries, Inc.; James G. Holland, Research Fellow in the Department of Psychology at Harvard University; and Paul B. Diederich, Research Associate at Educational Testing Service.

Those who attended the Conference also had the added pleasure of hearing James B. Conant, President Emeritus of Harvard University and Director of A Study of the American High School. In an informal talk after luncheon, Dr. Conant reported some of his experiences at the 1959 Salzburg Seminar for American Studies and discussed various aspects of comparative education.

I am pleased to express here my personal appreciation to all the speakers for agreeing to participate, for their cooperation before the Conference, and for their splendid contributions of fact and theory

on the various aspects of testing's impact on the educational process.

It is also my pleasure to thank Educational Testing Service, on behalf of all of us concerned with education and measurement, for its sponsorship of this annual event, which each year provides an outstanding forum for exchange of ideas on many different subjects and questions in the field of measurement.

DOROTHY ADKINS WOOD
Chairman

Chairman Dorothy Adkins Wood listens to Ralph W. Tyler's address.



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Arthur E. Traxler of Educational Records Bureau speaks at discussion period.



During the Coffee Hour preceding Session I of the Conference, two of the principal speakers at Session II discuss teaching machines and their use in education. On the left is Norman A. Crowder of Western Design; on the right is James G. Holland from Harvard University.

Session I

Remarks of the Chairman

DOROTHY ADKINS WOOD, Professor of Psychology, University of North Carolina

At this first session of the 1959 Invitational Conference, we shall consider some broad aspects of "The Impact of Testing on the Educational Process." We are fortunate in having three speakers, active in different areas of education, who will approach the topic in three different ways.

Our first speaker, Dr. Ralph W. Tyler, Director of the Center for Advanced Study in the Behavioral Sciences, is a man whose notable work in education, evaluation and research is well known to all of you. He will start the morning program with a general summary of "What Testing Does to Teachers and Students."

The second speaker at this session is a distinguished physicist, Dr. Walter C. Michels, Professor of Physics at Bryn Mawr College, who will approach the topic with a specific account of the impact of testing in one subject field. He will report to us, in a paper entitled "Some Lessons from High School Physics," precisely how testing became an integral part of one of the important educational projects of recent years—the Physical Science Study Committee's development of a completely new high school physics curriculum.

To conclude the morning session, we shall return to the more general approach, with the emphasis this time on education rather than on testing. Our third speaker will be Dr. Paul Woodring, one of the best known analysts and interpreters of the educational scene today, who will talk about "Education 1975." Dr. Woodring, currently serving as Educational Adviser to the Ford Foundation, taught in schools and colleges for many years before assuming his present duties—which give him an opportunity to visit schools and colleges throughout the country. It is most fitting, therefore, that Dr. Woodring should predict for us the educational changes we may expect to see during the next ten or fifteen years.

What Testing Does to Teachers and Students

RALPH W. TYLER, Director, Center for Advanced Study in the Behavioral Sciences

The use of testing to influence students is a long-established practice. Teachers have often been classified by their pupils as "tough" or "soft" in terms of the frequency and searching character of their examinations. Well-motivated students have commonly put extra time and effort into study when they thought they were soon to be tested. Quite probably, too, pupils having great difficulty in their school work felt even more incompetent when confronted with a test and, because it seemed too difficult, were not stimulated to study more effectively thereby. These differential effects of testing on students have been mentioned in the literature of teaching since the earliest years of publication.

With the advent of the "new-type" of test following World War I, questions began to be raised about the effects of short answer forms of tests in contrast to essay tests upon the motivation and study practices of pupils. A number of investigators sought through interviews and questionnaires addressed to high school and college students to find out whether the form of test used made any difference in their study practices. The results of these investigations, as typified by the reports of Douglass and Tallmadge (1) in 1934 and George Meyer (2) in 1935, showed that a considerable majority of the students reporting both in high school and college followed clearly different study procedures when they anticipated being given a "new-type" test from those followed when they expected an essay examination.

For a "new-type" test, the majority went over and over assigned material seeking to memorize every point, including specific details. For an essay test, the majority gave much less attention to specific details in the assignment and more attention to identifying a few major points around which they could write brief descriptive or expository paragraphs. These studies made it clear that students were strongly influenced in pre-

paring for tests by their perceptions of what the tests measured, that is, what behavior they would need to exhibit and with what content.

The Regents' Inquiry into the Character and Cost of Public Education in New York State, begun in 1936, provided objective evidence regarding the influence of testing on teachers as well as students. An intensive study was made of sixty-one school districts within the state, examining their curriculum guides and testing their high school students for several of the objectives specified in the curriculum guides. It was found that the achievement of the students paralleled more closely the objectives tested by the Regents' examinations than the objectives given major emphasis in the local curricula. Interviews with a sample of teachers in these communities revealed the fact that most of them were conscious of the objectives being tested in the Regents' examinations and sought to emphasize these kinds of learning in their classes rather than to follow the objectives recommended in the local curriculum guides.

My own experience in the Eight-Year Study corroborated these findings. When new ideas regarding the secondary school curriculum were advanced, we always found teachers raising the question of the relationship of these new proposals to the achievements which were being appraised by the College Entrance Examination Board Tests. Only through the arrangement worked out with colleges which permitted high school graduates to be considered for admission on the basis of scholastic aptitude tests and test data submitted by the schools in the Eight-Year Study were we able to get thoughtful consideration by the teachers of new curriculum proposals. Many were then able to shift from their previous practice of planning their teaching to correspond with their view of what would be required of their students on college entrance tests to planning based on judgments of the educational values of various kinds of learning.

A third kind of illustration of the influence of testing on students and teachers is the prevalence of coaching for tests. Some schools turn the junior and senior classes in the college preparation curriculum into coaching sessions several weeks before external tests are to be given. Some schools do not modify the teaching in the regular classes but arrange for special coaching for students planning to take these tests. In some communities, where no provisions for coaching are made in schools, some parents arrange for special coaching classes or for tutoring in the belief that this will aid their children to perform better on the tests. A quick examination of book stores and of advertisements also provides

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an indication of demand for coaching. Books and pamphlets purporting to help students pass important tests are widely sold.

Before concluding this brief review of the current influence of testing, mention should be made of the criticisms that are periodically raised regarding the effect of testing in intensifying the motivation of some students to an undesirable degree or attaching the motivation to undesirable objects. It is sometimes claimed that testing creates undue anxiety on the part of pupils who anticipate difficulties or inadequacies of test performance in comparison with their aspirations. This emotional tension, it is charged, not only interferes with successful performance on the test but increases the pupil's preoccupation with self-criticisms and distracts his attention from school work generally, thus lowering the effectiveness of his learning. A related criticism is that test scores are often seen by parents and children as ends in themselves in the competition to do better than their neighbors and to rise in the scale of social esteem. This obsession with getting high test scores attaches motivation to an external criterion rather than aiding the student to find satisfactions in learning and to become motivated to continue study and inquiry under his own steam.

The extent to which these criticisms are valid has not been established by comprehensive empirical studies, but there is enough case material to justify the conclusion that for some undetermined number of children, the anticipation of taking a test sets off an anxiety mechanism and that some parents use the results of tests as a means for rewarding or punishing children beyond the limits of common practice of teachers. It also seems clear from available cases that for many pupils and teachers, test performance is viewed as the major end of school instruction, rather than being a useful but not infallible indicator of student achievement.

I believe it is a fair summary of the current situation to say that tests have marked effects on many students and teachers. For pupils who have some confidence in their ability to perform on the tests, the knowledge that tests are to be given serves as a strong stimulation to study and the later report of their test performance provides a powerful re-enforcement mechanism of reward or punishment which helps to maintain the motivation for learning. Not only does testing afford forceful motivation but it also directs the efforts of many students and teachers toward learning activities which they believe are most relevant to what they think the test calls for. In many cases this may focus the attention

on goals different from those purportedly emphasized by the school and in some cases this results in "coaching" rather than long-term systematic instruction. Furthermore, testing can be a source of anxiety to some pupils and parents and can become for some the ends of education rather than a device for appraisal. Testing is a powerful instrument with potentialities for both good and bad.

When faced with this generalization, we who are concerned with the improvement of education and the effectiveness of learning must consider together how to achieve the maximum good potential in testing and to minimize or eliminate the bad. The problem cannot be met by denying the existence of the double-edged sword and by claiming that tests are "neutral" and are not in themselves agents for good or bad. Too much evidence of these varied effects of testing is available to disregard them, and so many teachers and school administrators have become concerned that steps of some sort will be taken. Wise action rather than no action should be sought. The problem cannot be met by advising schools to reduce sharply or eliminate testing. The need for more objective appraisals of pupil abilities and achievements for guidance and for curriculum evaluation as well as for instruction is even more widely recognized and the use of tests is on a very sharp increase. Testing will continue and the problem to be faced is how to conduct testing programs to derive the greatest benefits from them.

Since tests have a powerful directive influence on teaching and the study of pupils, a major policy to follow is to establish a testing program which faithfully reflects the objectives sought by the school. In this way the influence of testing is to re-enforce the other efforts of teaching. For a testing program to reflect faithfully the school's educational objectives, the tests used should not focus on behavior or content which is irrelevant to the school's purposes, but rather there should be included in the total testing program some appraisal of student achievement of all of the major objectives. This, of course, places a joint responsibility both upon the school and upon the producers of tests. The school in its selection of tests and in making clear its needs creates a demand for tests which appraise important educational objectives, while the thought, ingenuity and effort of test producers are required to develop and distribute the kind of testing instruments needed.

There is more to this policy than may be apparent at first glance. For a test or other form of evaluative instrument to be appropriate for a

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given educational objective it must evoke from the student the kind of behavior which is implied by the objective and it must also deal with the content which the objective implies. Thus, if one of the objectives of a social studies course is to develop an understanding of the concepts useful in analyzing the social structure of an American community, an appropriate test will require the student to show his understanding, that is, not merely to give or recognize a memorized statement of the concepts but to state them in his own words, to recognize examples, to give illustrations of the concepts and to compare and contrast related concepts. These kinds of behavior are commonly considered to be involved in understanding something. Furthermore, the appropriate test will deal with the concepts useful in analyzing the structure of an American community. A test of this sort can focus the attention of the student and teacher upon one of the objectives actually sought in the course rather than directing his efforts at some achievement irrelevant to it.

Or, as another example, if one of the objectives of a physics course in the school is to develop the ability of the students to apply basic principles of physics in explaining common physical phenomena and predicting the probable consequences of particular physical forces in action, then an appropriate test for this objective will require the student to explain various common physical phenomena using basic principles of physics in the explanation, and it will also involve exercises in which the student is expected to predict on the basis of his understanding of these basic principles what the probable consequences will be in various situations involving physical forces. If every major objective of the school is appraised by tests and other devices which are appropriate to evoke the desired behavior in connection with the specified content, then the testing re-enforces the school's efforts to attain its objectives rather than interfering with the learning desired.

However, it is not enough for the testing to reflect faithfully the educational objectives of the school. The pupils and teachers are directed by their perceptions of what the tests call for. When, at the Ohio State University, we began to use tests in biology which required students to apply biological principles in the solution of biological problems, the students looked at the tests and saw that the concrete situations described were not the ones outlined in the lectures, explained in the text or worked on in the laboratory. Because they thought of achievement tests as measuring their memory of material dealt with in the course, they

threw up their hands. These were questions which had not been answered previously in the course. So we spent some time explaining the purpose of each test and showing the kind of behavior required. This clarified the nature of the examinations used and also served to direct the students' subsequent study.

If the perceptions of students and teachers of the requirements of particular tests are to be accurate, more must be done than to give appropriate names to the tests. Manuals explaining what the tests involve are useful, and examples of test items with an explanation of the way each item is attacked help still more in clarifying perceptions, but demonstration testing sessions with explanations are also likely to be necessary.

In this connection most people have only a vague notion of the concept of sampling as it applies to the content and the situations included in a test. Hence, some teachers having seen one form of a test attempt to coach students on the particular items in this form. They fail to understand that comparable forms of a test will all require the same kind of behavior but each will draw its content and the particular test situations from the total universe defined by the objective which the test seeks to appraise. Thus, one form of a test will help to clarify the kind of behavior involved in all forms, but the learning and practice should be distributed over the total content and the variety of situations implied by the objective. The explanation and demonstration of this is an important part of the test manual, the sample exercises, and the discussion which takes place in the demonstration of the procedure for attacking the exercises in a test. This also serves to make the test as perceived by students and teachers a more accurate reflection of the educational objectives emphasized by the school.

Another policy which can increase the positive values of testing is to use similar tests periodically throughout the instructional program and to review with the students their performance on each test. This serves several purposes. It provides another means of explaining the nature of the tests and thus clarifying the educational objectives of the school. It reduces markedly the likelihood that the novelty of the test will affect the pupil's performance on it. This practice also reduces the emotional tension surrounding testing. Testing becomes a natural part of the total learning process rather than an infrequent and traumatic experience. Teaching machines which are in essence self-testing, self-

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scoring devices are widely interesting, even absorbing, to elementary and secondary school pupils. Much of the attraction of teaching machines lies in the immediate opportunity to test one's performance and to see how adequate it is. Tests properly selected so that the pupils who take them are able to demonstrate what they have learned, as well as what they have still to master, can help to build confidence in taking tests rather than to arouse anxiety.

Tests are here to stay and their uses will increase. They can be an obstacle to an effective educational program, distracting attention from the school's basic purposes, and arousing undue excitement and fear. On the other hand, because testing can increase motivation and provide an additional source of re-enforcement to learning, and because it can help to clarify the objectives of the school and focus effort on them, testing should be used as a positive factor in the educational program. To do so, the tests used should faithfully reflect the school's objectives, pupils and teachers should clearly perceive what behaviors the tests call for and what content they involve, and they should have continuing experience with appropriate tests to gain confidence in their ability to learn and to perform and to utilize the re-enforcement potential of the tests as an important dynamic factor in learning.

REFERENCES

1. DOUGLASS, HARL R. AND TALLMADGE, MARGARET. How university students prepare for new types of examinations. *School and Society*, 1934, 39, 318-320.
2. MEYER, GEORGE. Experimental study of old and new types of examinations. *J. Educ. Psychology*, 1934, 25, 644-661 and 1935, 26, 30-40.

Some Lessons from High School Physics

WALTER C. MICHELS, Professor of Physics, Bryn Mawr College

It is seldom that a testing program can be developed and put into effect under circumstances that are as nearly ideal as were the ones supplied by the Physical Science Study Committee experiment during the years 1957 through 1959. Some 300 students during the 1957-58 academic year, and nearly 13,000 students during the following year, were taking a new course. All were using the same textbook, following similar laboratory practices, and receiving preparation that was as close to uniform as the variety of schools, geographical factors, and teachers allowed.

The course itself had broken with tradition; its objectives had been thought out by a highly competent group of physicists before as much as an outline was prepared. Instead of being brought into the work through the Topsy-like growth that has led to many of our educational practices, each element of the course had been developed with the defined objectives in mind, and traditional subject matter that did not appear to contribute directly to these objectives had been ruthlessly cut out. Because the entire program was an experimental one, and because all of the teachers had shared the experience of special preparation, there was a degree of enthusiasm and of cooperation that is seldom present. Finally, sufficient funds were available to allow able people to be employed in constructing the tests, in analyzing the results, and in making such revisions as appeared necessary.

I think you will agree with me that this set of conditions comes very close to what Dr. Tyler has indicated is the ideal set of circumstances for a testing program.

For those who are not familiar with the Physical Science Study Committee (PSSC) program, it may be worth while to review briefly how this set of circumstances came into being. For a number of years professional physicists had become increasingly dissatisfied with the physics courses being given in the secondary schools. Under the pres-

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sure of a growing technology, these courses had become more and more pre-engineering *training* programs, "life centered" in that they dealt with the applications of physics. But they dealt little with the intellectual processes that had made the contributions on which these applications were based. How to return the physics courses to the rich cultural experience that students in the twentieth century have a right to expect was not clear until Jerrold Zacharias, in the summer of 1956—more than a year before Sputnik I—conceived the idea of tackling the problem on a big scale by bringing together the strongest group of minds that he could find to search jointly for an answer.

During the early work of the committee, it was decided that nothing less than a completely new syllabus, backed up by new supports—text, laboratory apparatus and guides, instructional films, supplementary reading materials, and special preparation of teachers—could serve the purpose. Before as much as an outline could be prepared, it was necessary that decisions be made as to the purpose of the course and as to the portion of the school population for which it would be designed.

Early in the game it was decided that this course was *not* to be fitted especially to the needs of those who would probably become scientists or engineers; it was to be aimed, rather, at the entire group that is capable of going on to higher education—say approximately the top third of the eleventh and twelfth grade students in our schools throughout the country. From this decision there followed the consequence that the course should aim at the development of an understanding of the processes of experiment, thought, and imagination that have characterized the growth of physical science, rather than at a mere mastery of the elementary techniques required of the practicing scientist or engineer.

With these decisions made, an exciting and busy year got under way in the fall of 1956. Outlines and ways of putting usable materials behind them were hotly debated. By the summer of 1957, a clear enough understanding had been reached to allow writing to progress, and a group of more than 100 people, including research physicists, teachers, professional writers, film producers, and others, gathered at the Massachusetts Institute of Technology for a concentrated summer's work.

By the fall of that year, part of the textbook was available in a preliminary form; one film was ready for showing; new and ingenious laboratory equipment and experiments had been developed. The course was certainly not yet ready for trial, but it was at the stage where the help

of the schools was needed for its further development. Eight teachers, each of whom had worked with the committee during the summer, arranged to give the course in their schools. In every case, the teacher had available as a consultant a university member of the committee, who maintained close contact with the classes and with the course.

It was apparent from the start that some sort of tests must be devised before a large-scale trial of the course was attempted. They were needed not only as a measure of the success or failure of the course in meeting the objectives that had been established, but also for a more important purpose. In the gradual drift that had led to the existing courses, too many teachers had come to think of their task as concerning only the presentation of facts and the drilling of students in the memorization of formalized statements or in the techniques of certain computations. If we were to encourage either teachers or students to break out of the walls established by tradition, it was essential that the former be supplied with a guide as to the kinds of questions that might lead students to think as junior scientists.

In view of this need for tests suited to the new course, it was fortunate that Henry Chauncey was a member of the original committee. Not only was his wise counsel of inestimable help; his enthusiasm for this radically new approach assured us of the best advice and cooperation available from those experienced in test construction, administration, and interpretation.

Among those working at Cambridge in the summer of 1957 were Frederick Ferris and Frank Fornoff from Educational Testing Service. I remember well some of the early sessions in which they and some of the physicists first came together. Many of us brought to those meetings our prejudices about tests. We were convinced that professional "testers" were bound together in a tight little bureaucracy designed to preserve its prerogatives. Probably I was among the worst offenders in this respect, for I had been, for several years, a member of a committee that had been conducting a running battle with the College Entrance Examination Board. We had complained that the examinations in current use were among the most pernicious of the devices for the stabilization of the *status quo* in high school physics, that those teachers who would otherwise be interested in and capable of improving their courses were forced by the examinations to continue with practices that they knew to be bad.

I strongly suspect that the representatives of the other side of the

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argument felt equally suspicious of us, convinced that we were speaking in complete ignorance of the technical and practical problems of testing and were even unwilling to grant that such problems existed. Eventually, however, we stopped moving in wary circles about each other, like dogs around a single bone, and we soon learned at least a working measure of mutual respect.

Probably the first genuine meeting of minds took place when we considered the Test of Developed Ability in Science, which had been constructed by the Board but had not found any niche for itself in the educational scheme. This test, with its emphasis on thought processes and on the ability to apply native or acquired skills to new situations, gave a sample, at least, of the kind of thing that would fit with the purposes of the new course. It is the direct progenitor of the ten tests that will this year be given to some 20,000 students taking the PSSC course. Eight of these ten cover specific sections of the course, each of approximately equal weight. The other two are designed to be part of end-of-semester examinations, emphasizing the unity of all physics.

A typical test consists of thirty-five multiple choice questions, built around six or seven physical situations. As far as possible, each situation is constructed to represent a real condition, for which the student can be expected to have some intuitive approach, as well as a purely logical one. He is led to analyze the situation in terms of the physical principles that he has learned, but only a small minority of the questions can be answered by the recall of statements made in the text and by no more than that. An attempt has also been made to minimize the importance of exact and involved arithmetical calculations. Whenever possible, the correct choice of an answer can be made on the basis of either qualitative reasoning or a very approximate calculation.

An example, used on the tests for the mechanics section of the course, may make this clear. The student is asked to suppose the existence of a number of boxes of identical exterior appearance, each of which is known to contain a single massive disc of metal. The boxes have different interiors, however. Some have smooth frictionless bottoms and others have rough bottoms; some have hard walls from which the disc bounces and others have sticky walls which trap it whenever it strikes. The student is also presented with a series of graphs, each of which shows the motion of a particular box over a horizontal surface as a result of a sharp blow, and he is asked to identify the type of box that corresponds

to each graph. These questions cannot be answered correctly unless the student knows about force, mass, momentum, and impulse; neither can they be answered correctly unless he can apply what he knows to a non-trivial physical system. The choice of answers may be made on the basis of qualitative information, such as whether the box moves continuously or comes to rest at intervals. Further, the set of questions tests the student's ability to read and interpret graphs and to visualize a situation of which he has a verbal description.

We have never dared to hope that a wide group of teachers would accept whole-heartedly tests prepared by a central agency, and our assessment has proved realistic. We have had some complaints about every test, ranging from criticisms of objectives to protests about the words used, and to challenges of the validity of whole sets of items. On the whole, however, the acceptance of the tests has been exceptional. A questionnaire circulated to the nearly 300 teachers who taught the course in 1958-59 was answered by nearly all of them. Their replies indicated that they had used the tests for much more than grading or ranking purposes. Many of them commented that the tests had given both them and the students a better view of what the course is trying to accomplish than could the text, the teacher's guide, and the laboratory manuals alone. Others found that discussions, during the first class period after the test had been given, served as an excellent teaching device, provocative of both thought and heated debate. The student reaction to the tests has generally been expressed in such terms as "difficult," "interesting," "fair," "different."

One of the major complaints received about the tests has been that they are too difficult. This undoubtedly results in part from the fact that teachers have been encouraged to discuss the tests after they have been given and, therefore, students learn their raw scores. In order to provide for reasonable discrimination near the top and bottom of the population, we have tried to keep the difficulty about at the level at which fifty per cent of the students give the correct response on an "average" question. In practice, and in the absence of time for pre-testing items, we have generally come up with tests that are slightly more difficult than we intended. When the average raw score for a class is less than one-half of the possible score, both teacher and class are likely to feel discouraged, if not frustrated.

Explanations of the intent and purposes of the tests, and of the fact

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that one cannot be expected to score perfectly when he is analyzing reasonably complex situations, have helped. One analogy that proved effective in dealing with this involved the statement that a quarterback who called his plays so well that the team scored a touchdown on one play out of four would be considered to be phenomenally successful. But, in spite of all efforts in this direction, it is certain that the psychological effect of low scores is serious and that we must probably sacrifice some discrimination at the upper end of the scale if we are to overcome it. As long as the tradition of a "passing mark" survives, some compromises will be necessary between the design of tests as tests *per se* and the design of the same tests as teaching tools.

The second complaint, which came from both teachers and students, particularly at the beginning of each year, has been that the connections between the tests and the subject matter of the course were so indirect that the questions tested aptitude, rather than achievement in physics. One student in the early fall of 1957, for example, remarked, "I stayed up late last night marking important facts in the text and memorizing them—not a single one of them was asked on the test." This criticism became less frequent as each year progressed, yet it was so prevalent at the beginning that we felt that it must be taken seriously. There seemed to be two ways of checking on its validity: 1) giving the tests to students who had not taken the PSSC course, and 2) finding the correlation between scores on these tests and those on tests that are recognized as tests of aptitude.

The first of these methods has not been easy to follow. It has been tried in one isolated case, in which all conditions except the specific physics course being taken were approximately equivalent to those under which the tests were originally administered. The results are probably not statistically significant, but they show average scores that fall between one and two standard deviations below those obtained by students in the PSSC course. I will not claim conclusive evidence here, but the indication is that the test scores do reflect preparation.

The second method yields results that are more conclusive statistically, but that offer difficulty of interpretation. The School and College Ability Test was taken, in its short form, by the students in a test group of schools during the fall of 1958. Correlations between these scores and those on all of the PSSC tests given during the year were obtained. The results for nine of the tests are shown on the following page.

WALTER C. MICHELS

Test No.	Subject	Correlation Coefficient
1	Time, space, and motion	0.51
2	Mass, atoms, and molecules	0.54
3	Optical phenomena	0.41
4	Waves	0.45
5	Semester I test	0.40
6	Mass, force, and momentum	0.44
7	Energy	0.37
8	Electricity	0.24
9	Semester II test	0.38

Considering the fact that the statistical reliability of the tests themselves was about 0.80, the low correlations between them and the well calibrated SCAT scores causes one to raise his eyebrows. The tests are certainly not measuring aptitude if we grant the SCAT scores are indicative of that quality. When one remembers that the correlation between the CEEB regular physics test and the Scholastic Aptitude *Verbal* Test is 0.61, the figures given above are abnormally low. The fact that the correlations show a general decrease as the year progresses is even more surprising. If there is one result of the analysis of our tests that invites study, thought, and interpretation, this is it!

One possible explanation of the conflict between the evidence of the correlation coefficients and the subjective opinion of some of the teachers is that our new tests may be so badly constructed that the scores obtained in them are indicative only of a special "testmanship" skill on the part of the student. This supposition might account for the decrease in correlation during the year, as the students of low aptitude develop this skill with repeated tests of the PSSC type. Perhaps we are testing Skill X, rather than knowledge and understanding of physics. On the other hand, both the raw scores on the tests and the distribution of those scores have remained quite stable throughout the series of tests—if anything, the mean raw score moves downward as the year progresses and the spread becomes greater, relative to the mean. This does not seem to be consistent with the hypothesis, and the correlation of about 0.50 at the very beginning of the year is certainly very low if we suppose that we are dealing with a skill peculiar to our tests.

The only explanation that we have been able to reach thus far—and it must remain a tentative one until it can be checked—is that the condi-

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tions under which these tests have been developed have allowed the measurement of a valid mental factor that does not affect strongly the scores on existing CEEB tests. If so, we are almost forced to the conclusion that the high correlation among the various CEEB achievement tests, and of each of these with the Scholastic Aptitude Tests, indicates that we are examining the same factors over and over again, merely increasing the reliability of measurement of one dimension while neglecting other dimensions completely.

The commonly stated objections to multiple choice tests, that they call for specific knowledge, for speed of response, and for a certain skill in outguessing the examiners, are in line with this conclusion. These objections may not be completely valid, but they are stated so frequently by instructors at all levels that we cannot discard them as being founded entirely on misconceptions. Further, even a casual examination of what we demand of students in nearly all of their courses supports the idea that the same few mental qualities are demanded for a moderate degree of success in highly diverse subjects. A retentive memory and a willingness to work hard may not assure a student high grades, but they will allow him to pass nearly all courses at the school level and many at the college level. Anyone who has taught knows that qualities of imagination, originality, and tight reasoning are sufficiently rare to call pronounced attention to themselves when they appear. They are not easy to test on examinations that are suitable for a majority of the class, and we are inclined to think of them as exceptional gifts.

Whether the PSSC tests measure any of these qualities that I have mentioned is a question that cannot be answered at the present time. The objective evidence is nil. A number of teachers and physicists who have examined the tests have expressed the opinion that we do get at something of the sort, but there is one specific reason for distrust of this subjective judgment. Almost invariably, the same persons raise the question of speed, explaining that they cannot answer at the rate of one item every seventy-five seconds and that they do not see how students arrive at the answers as rapidly as they do. This may indicate that the students use a different mental process in making their choices than do more mature workers. Definite evidence that this is so would support the supposition that I have tentatively discarded—that of a special testmanship skill.

Even if we grant that circumstances and good fortune have enabled us to make successful measurements of a set of one or more mental quali-

ties not conceived by the usual CEEB program, we have, as yet, no objective evidence as to whether these qualities can be developed by appropriate teaching, or even whether they are important in predicting success in college. In another year or two it will be possible to follow the college careers of students who have taken the PSSC course and, perhaps, to make comparisons of their performances at the two levels. Because the course is not designed primarily to prepare for further work in physics, such comparisons must be made over the entire field of studies, and their interpretation may well be complicated by the presence of the wide variety of emotional and mental factors that play so big a role in the transition from school to college. Various plans for the follow-up study have been considered, but no thoroughly satisfactory one has yet been proposed.

I do not want to close without touching on one particular test of the 1958-59 series. Because of our emphasis on the *use* of knowledge, we decided to include in the tests some items that could be expected to show almost zero dependence on the detailed subject matter of the course. All the *information* necessary for these items is stated briefly but completely in the test itself. Questions of this sort were included in many of the tests, but one test involving items of no other kind was given as a Test of General Objectives at the end of the first semester. The situations developed in it included one that gave the students data that support Einsteinian kinematics rather than the Newtonian kinematics that they have studied; in another, the polarizing properties of crystals were illustrated, although essentially nothing about polarized light is included in the course. This test was an extreme application of the attitude that had determined the nature of the rest of the series. It minimized the importance of pure recall and demanded the application of the techniques, principles, and skills that the course had attempted to develop.

We were quite convinced that the thought required by the Test of General Objectives could not be carried out as rapidly as could that needed on the other tests. We therefore limited the test to twenty-five questions, instead of thirty-five, allowing just short of two minutes per question. The small number of items and the use of only three different situations on which the questions are based undoubtedly contribute to the fact that the statistically estimated reliability of this test was only 0.63, as compared with the figure of about 0.80 for the other tests. The correlation between the SCAT scores and those on the Test of General

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Objectives is 0.48, slightly higher than the 0.40 figure obtained for the Semester I test, taken at the same time. If the difference is taken seriously and is interpreted in the light of my tentative assumption, it would appear that the Test of General Objectives was not as successful in measuring the hypothetical factor as were the other tests.

This is certainly not the result that was anticipated on the basis of the construction of the tests. Even more surprising is the fact that the Test of General Objective, and the Semester I test show a correlation of only 0.54. This is considerably lower than are the correlations between pairs of the regular PSSC tests. Can it be that there are two new factors involved here, almost independent of each other and both almost independent of the factor tested by standard aptitude or achievement tests? I should hesitate to draw any such conclusion on the basis of the scanty information yet available, yet the results are suggestive of it.

Certainly we do not have enough information to justify any dogmatism about the effects of the PSSC course or about the nature of the tests that it has allowed to be developed. On the other hand, we can say that a repetition of the experience of the past year during the coming one would tempt us to conclude that much of the teaching and testing in the past has been channelled very much down a single groove, in which we are not taking advantage of the peculiar contributions that different subjects can make to the intellectual development of the student. Further studies of the results obtained on the regular tests, the development of better tests of general objectives, experience with other subjects than physics, and some method of following the students into college are clearly needed. The first two of these are under way; the third may become increasingly possible as some of the other courses being developed with the support of the National Science Foundation come into use. Any suggestions from this audience of ways in which the last can be accomplished will be highly appreciated by all of us.

Education 1975

PAUL WOODRING, Educational Adviser, The Ford Foundation

The theme of your conference is *The Impact of Testing on the Educational Process*. I shall not talk about testing, however, because this is a field in which all of you are better qualified than I, and one with which other speakers will deal. I shall discuss the educational process itself, the impact of recent social change upon this process, and some of the foreseeable and hoped-for changes in the schools.

It is essential that the changes of the years ahead be planned and made by people who know the facts, have a clear educational philosophy, and take a careful look at the enormous problems facing us. The attempts to get the facts and to understand the problems is greatly complicated by the fact that there is, strictly speaking, no such thing as the American educational system. When the Founding Fathers wrote the Constitution they did not use the word "education" anywhere in the document. The result is that we have fifty separate state systems of education. Some states exert a good deal of influence over the schools within their domain, while others provide only loose control and limited state support. Within the limits of the restrictions imposed by the separate states, the schools are under the control of local boards of education which govern units ranging in size from one-room country schools to that of New York City with more than a million pupils in thirty thousand classrooms. There are fifty thousand of these separate school boards and each, within broad limits, is a law unto itself and a policy making body. No other nation has so much local control of education.

The various states differ widely in their requirements of standards for graduation, requirements for teacher certification, salary scales for teachers, and funds made available for education. Even within a single state there is great diversity. One city may have very high standards and another, in the same state, very low standards. A high school diploma from one high school may give evidence of high scholarly attainment, while another in the same city may indicate only that the student has been present for four years.

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As a result of this vast diversity, any statement about American education, or any criticism of it, is probably true in some schools and quite false in others. Much of the endless debate about our schools is the result of this fact because no critic, observer, or defender can have an adequate knowledge of all the schools and, quite naturally, each one generalizes from a few schools he knows at first hand.

There seems little doubt that we have some of the best schools in the world, and some of the worst. Some of our teachers are geniuses and some are not as bright as the pupils in their classes. Some of our school buildings are magnificent and others, which may be in the same city, are a disgrace to the community. Some high schools and colleges offer a rigorous academic curriculum, others offer a softer diet, and still others use the cafeteria approach with something for everyone, regardless of his interests or abilities.

Despite the loose-jointedness of this organization, it does not seem likely that it will change very much in the foreseeable future. It coincides too closely with our concepts of democracy, freedom, and local self-determination, and with what Frederick Lewis Allen once called "The Unsystematic American System."

Apart from diversity, the two most conspicuous characteristics of the American educational establishment are: 1) its vast size, and 2) its complexity.

The size can be reported as a statistic: forty-five million students—one-fourth of all the people in the nation attend our schools and colleges. Of these, thirty-four million attend public elementary and secondary schools on a full-time basis. The teaching of these pupils requires the full-time employment of one and one-fourth million teachers—one out of every fifty employable adults in the United States.

The complexity cannot be reported in such simple terms. We have nursery schools, kindergartens, elementary schools, junior and senior high schools, junior colleges, senior colleges, universities, and a large variety of professional and technical schools. At each of these levels we have public, private, and parochial schools, and today the parochial schools are growing more rapidly than the public schools.

Each level has grown more or less independently and the parts have never been organized into an articulated pattern. There has never been much cooperation, or even communication, for example, between the people responsible for college education and those responsible for ele-

mentary education, and not nearly as much as there should be between high school and college people. A major problem of the years just ahead is that of eliminating the waste and duplication now found among the various overlapping units. A still more important problem is that of deciding just where we are going, want to go, and ought to go.

The American people have long believed deeply in the doctrine of progress—the doctrine that the world is getting better all the time, or will become better if only we all lend our efforts to the right causes. This doctrine is closely related to the liberal's belief in the perfectibility of man, a belief which, as Harold Taylor has pointed out, must withstand a fair amount of contradictory evidence. Despite this evidence, most of us believe that man and his world can be improved and that one road to improvement lies in more and better education. Sometimes we have seemed almost to believe that education is the only road to social betterment and this belief has led us to assign to the schools many tasks that may fall outside their proper range of responsibility, including some that are not educational at all. It has led us to confuse therapeutic, custodial, and recreational responsibilities with educational ones and sometimes to put them before educational ones, with a resultant decline in intellectual emphasis within the schools.

Confusion about the assignment of priorities to the schools lies at the source of much of the controversy of recent years and provides the basis for the dilemma in which we now find ourselves. Until we decide what is most important it will be impossible to decide whether the schools are doing their work satisfactorily.

The improvement of education, like any form of social change, occurs in waves with periods of relative stability, or perhaps we should say stagnation, between the periods of reform. Within the memory of living man this process has come full cycle.

The decade of 1920 was one of rapid educational reform, particularly in the lower schools, and many of these reforms may loosely be placed within the category of progressive education. In some areas these reforms continued well into the 1930's, but by 1938 it was clear to Bode, Dewey, and other writers, that the wave had spent itself and that the reform movement was fraying at the edges. Aberrations crept in which did much to offset the gains of the progressive movement and to make it appear ridiculous in the eyes of the observers.

The period from about 1938 to 1948 or 1950 was one of comparative

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stagnation while the American people turned their attention to war and other things. The schools grew somewhat during this period, but there were not many new ideas.

The decade of the fifties has been one of re-examination and re-evaluation. During these years the American people have taken a long, hard look at their schools and at the culture that moulds them and is nourished by them. They were far from fully satisfied with what they found and the years have been highlighted by vigorous attack and counterattack.

During any period of reform, or just prior to it, the people most concerned divide themselves into conflicting groups, one of which urges change while the other defends the status quo or the recent past. This division has been apparent during the 1950's, but there has been a most curious reversal of roles. In the 1920's the leaders of progressive education were the most vigorous critics of America's schools, which they branded stodgy, undemocratic, illiberal, and reactionary. The principles of progressivism were never more than partially absorbed into the American educational system. Yet when the attacks upon the schools came in the 1950's, the "progressives" and their half-hearted offspring and followers who had come into positions of leadership found themselves in the embarrassing position of defending the status quo in the schools and insisting that the schools were not nearly as bad as the critics said. Some of them insisted that there really was nothing wrong with our schools, or at least nothing that a little more money wouldn't quickly cure. And so the "progressives" became the conservative force while still bearing all the progressive and liberal labels. This has been a source of much confusion and has caused the decade of controversy just ending to be much less edifying than it ought to have been.

Since World War II the terms radical, progressive, liberal, conservative, and reactionary have lost much of their original meaning in education, as they have in politics. But if a radical is defined as one who would do violence to the status quo, it is such critics of the schools as Hutchins, Rickover, and the Council for Basic Education who are the true radicals in education today. Although some of them occasionally go to Europe, and even to the Middle Ages or the Greeks for their models, this is little more than a literary device, for the kinds of schools they are proposing bear little resemblance to anything existing in the past.

By the same token, today's educational conservatives are those

professional leaders who are prone to defend the existing schools with their proliferated activities and their emphasis on permissiveness and the "whole child" concept. This is conservative because it is a defense of that which has existed for the past thirty years, and because the defensive posture does not lend itself to constructive change.

A basic difference between the defenders and their critics is that the critics call for a sharper definition of education and a focus upon intellectual activities, while those who resist the attacks must defend a wide variety of peripheral activities, which however important they may be are not strictly educational in nature but may be more accurately defined as custodial, therapeutic, or recreational.

The solution to this conflict is an essential first step toward educational progress. It will require the best thinking of people who know the facts and are able to analyze the cliches that have retarded educational thought in recent years.

It is true that the "whole child" comes to school and the teacher cannot safely ignore symptoms of ill health or emotional disturbance. It is true that some forms of recreation may have educational value. But at three in the afternoon the "whole child" goes home. On Saturday the "whole child" goes to the dentist, but we don't ask the dentist to teach him to read. The fact that the child develops as a whole does not logically lead us to the conclusion that the school, or any other one institution, must accept responsibility for all aspects of this development. Each institution should undertake to do those things it can do best and which are specifically assigned to it.

It is not at all likely that the public schools of America will ever *limit* themselves to intellectual activities. But they must establish priorities and put first those things that should come first. The recent critics of the schools have some curious blind spots, but on one basic issue I think they are correct. They have said that the school should devote its major time, money, and energies to those things that clearly are educational in nature, that no other institution can do as well, and that are likely to be neglected altogether if the school fails to do them. These are the things that are intellectual in nature and in which the learning process is most deeply involved.

A public school may, if it wishes, and if the people are willing to foot the bill, provide a great deal of entertainment for children and for adults in the community, as the typical high school does today. It may

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offer athletic contests, marching bands, cheer leaders, and drum major-ettes which provide exercise for a few and entertainment for thousands. But this is not the school's primary task. We get better entertainment from professional athletics, television, radio, and motion pictures. Even if the schools offered nothing of the sort, we still would be the most entertained nation in the world.

The school may, if it wishes, provide mental and physical therapy for those who need it, as many do, but schools should keep in mind that this, too, is a secondary task of an educational institution. Therapy is the primary task of the medical profession and clinical psychology. The fact that therapy is unquestionably important for many children, and for some must precede learning, does not alter the fact that the school is an educational, not a therapeutic institution and, despite some overlapping, a useful distinction can be made between the two.

The major energies of the school should be devoted to producing the educated individual and the educated individual, in the words of the Harvard Report, is one who has been liberated from "the limitations of ignorance, prejudice, and provincialism." He takes a broader view of the world and sees it in perspective.

But an essential aim, indeed the ultimate aim, of education in a free nation is that of preparing the individual to make wise, independent decisions—all kinds of decisions, in the home, on the job, in the voting booth, and on the jury panel, decisions required in planning a good life and conducting it properly. To know is important, but not enough. The free man must be able to choose—if he cannot make decisions for himself he is not really free, however benevolent the guidance and the controls may be.

Decision making is not to be approached directly, at least not at the lower levels of education. As a first step the child must learn to read rapidly, selectively, and with understanding, and this is the primary (not the exclusive) aim of the elementary school, for all else is dependent upon it. Reading opens the door to a lifetime of learning. But reading, or the three R's as a group, is not the goal of education; it is but the first essential step toward the goal.

As a second essential step the child must gain an understanding of man and of his world—he must gain a tremendous amount of accurate information on a wide variety of subjects. For purposes of instruction this information and the deeper meanings derived from it has been

divided into the academic disciplines which are taught in the schools. Whether these disciplines are most effectively taught as separate subjects, or organized into broader patterns, or grouped into great ideas is debatable, but there is no question that the school is responsible for passing on to the young the wisdom and knowledge of the ages. It is thus that the cultural continuity is maintained.

With this background of essential information the student is ready to begin to learn to think logically as a final step toward the all-important aim of solving problems and making the decisions that confront him as a free man.

If we can agree on the priorities of education, perhaps we now are ready to bring about such changes in the schools as will assure the achievement of the most important goals.

Let me risk a few predictions about the probable changes in our schools that will occur during the next ten or fifteen years. Although the crystal ball is inevitably cloudy, these are not mere guesses, for all the predicted innovations may already be found in some American schools and are spreading very rapidly.

First, the structural changes. It seems probable that the present ladder system, under which each child advances one grade each year and all graduate at about the same age, will be replaced by a more flexible arrangement so that each child can advance at his own best rate. This will require a great deal of accurate testing all along the line—aptitude testing, achievement testing, and personality evaluation. Probably the lower elementary grades will be replaced by the ungraded unit and the kindergarten, which has long been a dangling appendage, will be absorbed into this unit.

In the secondary school, which the student will probably enter and leave a year or two earlier than he does today, students will be grouped on the basis of ability in each separate subject so that a student may be in the fast class in one subject and with a slower group in another. In most parts of the country this will be done within the comprehensive high school so that all students of an age or maturity level will be together for social and recreational activities.

There will be a great deal of experimentation with class size. We shall no longer assume that a class of twenty-five or thirty is best for all age groups and all subjects and methods of instruction. Some classes will be larger and some smaller, depending on the nature of the activity.

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The content of some subjects, notably science and mathematics, will be greatly altered and brought up to date. The new approaches to the teaching of foreign language in the elementary school will spread across the country.

Educational television will bring some of the best teachers to millions of children. There will be continued efforts to improve the quality of this instruction and to coordinate it with classroom activities. The limitations of television instruction have been much emphasized, but we have not yet given sufficient attention to its tremendous possibilities. It is true that the child cannot ask questions of the television teacher; he cannot ask questions of the textbook either, but this has never kept the book from being a useful educational device. But the responsibility for television must be placed in the hands of scholarly teachers—television should never be thought of as just another audio-visual aid.

Some of the smaller high schools will be consolidated. But where consolidation is unfeasible because of geography, there will be new efforts to make the small school a good school instead of asking the student to spend many hours each day on a bus. By making proper use of educational television, sharing specialist teachers among several schools, and providing correspondence courses for the gifted, we shall find it possible to provide excellent education even for children in remote areas.

We are discovering that a school can be too big as well as too small. Some of the larger high schools, perhaps all of them with enrollments over 1200 or 1500, will be broken up into smaller units of about 400 students each. This so-called "house plan" is now found at Newton, Massachusetts, and Fairfield, Connecticut, where several of the smaller units are placed on a single campus. Several of these units use the same gymnasium and auditorium at different times of the day, thus materially reducing the cost of these items, and library and laboratory facilities may be shared. But each unit will have its own teaching staff and will be a separate social and educational unit.

In the next ten or fifteen years enrollments in our colleges will double. There is not much guesswork about this, the babies are born and have been counted, and the percentage wanting to go to college seems certain to continue to rise. Private colleges will be unable to accept their share of the increase and the load upon the state colleges will be enormous. There will be an acute shortage of college teachers, for we shall be

attempting to educate students born during a period of high birth rate with teachers born a decade or more earlier during periods of low birth rate and there just won't be enough to go around. Salaries will rise dramatically, but even this will not solve the problem.

Entrance standards will become more rigorous and remedial courses in English and mathematics will probably be dropped from the college curriculum. With fewer teachers in proportion to the number of students, more responsibility will be placed on the student. There will be less spoon feeding and more emphasis on individual study; the student unable to accept individual responsibility will have a rough time.

At all levels of education there will be a great deal of attention to the reallocation of space, time, and personnel in the schools and this will do much to improve the efficiency of the educational system.

But these changes, however important they may be, are of form and not of substance. They provide the means for bringing better education to all children but they do not assure it.

The most basic question is not "how is the school organized" but "what goes on within it?" What does the child read and think about and discuss with his classmates? In what ways is he a different person as a result of his educational experience? What has he learned in school that he would not have learned elsewhere?

The most all-embracing change of the coming years—one that stems directly from the controversy of the past decade—will be a new emphasis on the *quality* of education at all levels. The need for this emphasis was noted two years ago by William Carr, Executive Secretary of the NEA, when, commenting on the hundredth anniversary of that organization, he said, "... just as quantity was the primary goal (of the NEA) for the first century, quality will be our chief aim for the second. We have been concerned with getting every child into school. Now we must ask how much each child gets out of school."

This new emphasis on quality is behind much of the current demand for more homework and more attention to the "hard" subjects. In many places the emphasis is necessary because some of our schools have indeed grown soft. But quality in education cannot be assured merely by piling on more work. Quality is achieved only when the child is led to think more deeply and about more important things, to ask more basic questions and to pursue their answers more diligently.

The achievement of quality will require a new kind of teacher, more

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resolute and purposeful, more intellectually vigorous. He must understand children and the learning process and must know how to teach, and this will require improved professional preparation. But he must, at the same time, have a firm knowledge of his subject and a broad grasp of the world of ideas. He must, indeed, be liberally educated in the best sense of that term. He will not be afraid to be an intellectual and will be willing to set high standards for all children capable of achieving them. He must be intelligent enough to discriminate between the important and the trivial, and tough-minded enough to stand up against the anti-intellectual forces of our culture.

Ideally, all teachers should possess these traits. But it would be optimistic to suppose that we can find enough for one and a half million classrooms. We may, in time, find it possible to supply enough fully certified teachers, or enough teachers with five years of college education, but it is not likely that we shall find enough teachers capable of high level intellectual leadership. Yet each child is entitled to the opportunities afforded by continued study under such a teacher.

The solution will probably be found in team teaching. Not every teacher can be a master teacher, but one member of each team can be.

Instead of one teacher responsible for twenty-five or thirty children in a self-contained classroom we shall have a team of five or six adults, with varying degrees of professional education and experience, responsible for the education of 100 or 150 children. A team may be responsible for the total education of a group of children selected on the basis of age or maturity or, particularly at the secondary level, it may be responsible for the teaching of a broad field: such as languages and literatures, science or the social sciences.

In either case the team will consist of one or more master teachers, one of whom will be the team leader. These master teachers will be fully qualified and carefully selected individuals who are committed to the profession of teaching as a lifetime occupation. They will be paid much higher salaries than are now paid to any classroom teachers and the availability of such openings may provide the solution of the merit pay problem, for they will make it possible for a teacher to achieve a professional level of pay and responsibility without leaving the classroom.

One or two other members of each team will be fully certified teachers, as well qualified as the teacher today. Some of these will be married women, well qualified in terms of general education and personal traits

but whose family responsibilities make it necessary for them to teach intermittently rather than regularly.

Other members of the team, who may be employed on a part-time basis, will include members of the community who have special skills and talents useful in the classroom, but who have no professional preparation. The team plan will make it easier to employ the talents of these individuals. Changes in certification laws, and laws regarding state aid, will be necessary, but these will be made.

Each team will include one secretary or teacher-aide who need not be a college graduate but who can accept responsibility for many of the non-professional tasks that now take up much of a teacher's time. The teacher will then be free to teach.

Finally, each team will include an intern who is getting his first classroom teaching experience in a realistic situation. His work will be continually supervised by the master teacher and because the master teacher is present all the time there will be far better and more continuous supervision than is now available to most practice teachers. The intern will be present all day for a semester and will probably receive a salary. This procedure has been in operation for several years in several schools in Massachusetts working with Harvard and is now spreading to many parts of the country. In most cases the intern is already a college graduate and the seminars which he takes during his period of internship may be counted toward the Master of Arts in Teaching degree.

The preparation of the kind and numbers of teachers needed for 1975 will require the best efforts of all our colleges and universities, for even today the institutions called teachers colleges, or colleges of education, produce only about 20% of all the teachers needed. It seems clear that the distinction between the teachers college and colleges of other kinds is fast disappearing as teacher education is brought into the mainstream of higher education in America.

As the people continue to give more attention to the importance of good teaching, the prestige of the teaching profession and of the teachers college will rise rapidly. By 1975 the notion that a teachers college is a second rate institution will have become an anachronism—any institution that continues to be other than first rate will no longer be allowed to prepare teachers.

In making changes we must take care not to lose our link of continuity with the past—not to jettison our cultural heritage. The schools and

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colleges of yesterday and today are an important part of that heritage. Santayana has reminded us that progress depends on retentiveness no less than on change. "When experience is not retained," he says, "as among savages, infancy is perpetual. Those who cannot remember the past are condemned to repeat it."

With this caution in mind let us set out to give intelligent direction to the changes in education that are now forced upon us by social change, technological developments, population pressures, external threats to the nation, and the demand of the American people for better education. Let us move with the changing times and build an educational system better than our nation, or any nation, has ever known.

Session II

Remarks of the Chairman

This afternoon we turn to some specific devices relating to the theme of today's Conference. Certainly the impact of testing on the educational process is nowhere more evident than in the machines and exercises developed to test the student as he learns—or, to put it another way, to facilitate his learning by enabling him to test himself as he learns. We shall now hear about some of the recent work being done in this area.

Our first speaker is Norman A. Crowder, Manager of the Training Systems Department at Western Design, a division of U. S. Industries, Inc. Mr. Crowder was associated with the United States Air Force from 1951 to 1958, where he was primarily concerned with personnel problems associated with the maintenance of complex equipment. Before that, he had been a Research Associate in the Department of Education at the University of Chicago. He will talk today about "Intrinsically Programmed Teaching Devices," with particular emphasis on the automatic tutoring devices developed at Western Design.

No program of this sort would be complete without a presentation of the technology of education developed by B. F. Skinner and his associates at Harvard. Our second speaker this afternoon is Dr. James G. Holland, a Research Fellow in the Department of Psychology at Harvard University, where he works closely with Dr. Skinner. Dr. Holland has devoted much of his own research work to the area of learning theory, motivation and perception. His paper is entitled "Teaching Machines: An Application of Principles from the Laboratory."

Still another kind of teaching-and-testing device will be reported by our third speaker this afternoon, Dr. Paul B. Diederich, Research Associate at Educational Testing Service. Anyone familiar with Dr. Diederich's career as an English teacher, and his keen interest in developing ways to improve the teaching of English, would guess that his report has something to do with the field of English. And so it does. He will tell us about the new exercises being developed to provide "Self-Correcting Homework in English."

Intrinsically Programmed Teaching Devices

NORMAN A. CROWDER, Manager, Training Systems Department,
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"Automatic tutoring" is an individually-used, instructorless method of teaching which represents an automation of the classical process of individual tutoring. The student is given the material to be learned in small logical units (usually a paragraph or less in length) and is tested on each unit immediately. The test result is used automatically to control the material that the student sees next. If the student passes the test question he is automatically given the next unit of information and the next question. If he fails the test question, the preceding unit of information is reviewed, the nature of his error is explained to him, and he is retested. The test questions are multiple-choice questions and there is a separate set of correctional materials for each wrong answer that is included in the multiple choice alternative. The technique of using a student's choice of an answer to a multiple-choice question to determine the next material to which he will be exposed has been called "intrinsic programming."

The intrinsic programming technique can be implemented with a number of specific devices. The simplest device is called a "TutorText." This is a specially prepared book in which each answer choice is identified with a page number. The reader, choosing a particular answer, turns to the page number given for that answer. There he will find either the next unit of information and the next question, or, if the answer he chose was incorrect, he will find the correctional material appropriate to the answer he chose. He will then be referred to the original choice page to try again. The page numbers in the book are assigned essentially at random and the reader, therefore, cannot progress from one page to the next except by making an active choice of an answer.

A more sophisticated device for handling intrinsically programmed materials is called the Tutor. The Tutor presents the material in micro-

film (still) and/or motion picture form and prints on paper tape a complete record of the student's sequence of choices and of the amount of time spent on each. A more detailed discussion of both the Tutor and the TutorText is given below.

There are a number of other possible devices that can be built to handle intrinsically programmed materials. For example, such material can be adapted to an aural presentation as well as a visual presentation, or combinations of both may be used. The basis, or defining feature of the method, however, is the use of the student's choice of an answer to a multiple-choice question to determine the next material to which he will be exposed.

Rationale

The person who creates a "teaching machine" might seem to be claiming that he understands human learning in sufficient detail and generality that he can set up, via the machine, those conditions under which efficient learning will inevitably occur. However, we who work with intrinsically programmed devices do not have access to any such educational philosopher's stone. Rather, we suspect that human learning takes place in a variety of ways and that these ways vary with the abilities and present knowledge of different students, with the nature of the subject-matter, with a number of interactions between these sources of variation, and with other sources of variability of which we are not even aware. Why, then, do we presume to build "teaching machines" at all?

The answer lies in the feedback control which is inherent in the intrinsic programming method. To predictably achieve a desired result, one must either have an infallible process to bring about the result, or one must have a means of determining whether the result has been achieved and of taking appropriate action on the basis of that determination. This latter capability is the basis of the intrinsic programming, or automatic tutoring, technique. The automatic tutoring devices require the student to respond to the material presented, and the devices in turn modify their behavior (exposing new and different material to the student) until the desired result is obtained.

It is worthwhile to point out that the process we are describing is different from that of simply furnishing "knowledge of results" to the

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student. The test result is used to control the behavior of the teaching machine and need not necessarily be furnished to the student at all. The student may incidentally learn whether a given answer was "right" or not, and presumably this is usually desirable, but the furnishing of this "knowledge of results" to the student is not the primary purpose of the testing. The primary purpose is to determine whether the communication was successful, in order that corrective steps may be taken by the machine if the communication process has failed.

Actually, the paragraph above is unnecessarily restrictive, since the concept of "rightness" or "wrongness" of a student's choice of answers is not always applicable. In general, the intrinsic programming technique allows us to produce a device which "responds appropriately" to what the student does. In teaching context, "what the student does" is ordinarily appropriately categorized into "makes right response or responses" (since there may be several right responses) or "makes one of several kinds of errors." Therefore, we spoke above of proceeding to the next topic or taking corrective action, as would be appropriate in the teaching context. However, the basic technique is applicable to quite a variety of situations in which a device is required to interact with a human being. TutorTexts have been written which play bridge with the reader and the Tutor could be programmed to play quite a powerful game of chess, if we were allowed to restrict the human player's choice of moves to the relatively few sensible ones available at any given time.

A final word on the origin of the term "intrinsic programming," and we will turn to specific discussion of devices and techniques. Evidently any teaching machine that employs a flexible program must have some means to control the exposure of the material on the basis of the behavior of the student. Gustave J. Rath, Nancy S. Anderson, and R. C. Brainerd (1) have described an experiment in which the student's response was automatically fed into an IBM 650 computer and this information, along with stored information in the computer, determined the next material to which the student would be exposed. In this case the programming device is an external computer and the method, in our terms, would be one of "extrinsic," rather than "intrinsic" programming. The term "intrinsic programming" simply refers to the fact that the necessary program of alternatives is built into the material itself in such a way that no external programming device is required.

Techniques

The variety of types of programs that can be prepared in intrinsically programmed form is limited only by the ingenuity of the programmer. The technique itself will accommodate any branching program that depends on the history of the student's choices, although in practice practical limitations on the bulk of the material to be prepared must be considered. The simplest form of program step is one in which each wrong answer refers the student (after further discussion) back to the original choice page to try again. An example of such a step would be:

(From Page 101)

"Now, you recall that we had just defined

$$b^0 = 1$$

for any b except where $b=0$. We had reached this definition by noting that our division rule,

$$\frac{b^m}{b^n} = b^{(m-n)}$$

will give b^0 as a result if we apply it to the case of dividing a number by itself. Thus,

$$\frac{b^3}{b^3} = b^{(3-3)} = b^0$$

but $\frac{b^3}{b^3}$, or any number (except 0) divided by itself equals 1, so we defined $b^0 = 1$.

We used a division process to find a meaning to attach to the exponent 0. Very well, let's see what other interesting results we can get with this division process. Let's apply our division rule to the case of $\frac{b^2}{b^3}$. What result do we get?

ANSWER

Page

$$\frac{b^2}{b^3} = b^1$$

94

$$\frac{b^2}{b^3} = b^{(-1)}$$

115

The rule won't work in this case

119"

The student who elects to turn to page 94 will find:

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"Page 94

"YOUR ANSWER: $\frac{b^2}{b^3} = b^1$

Come, come, now. The rule is $\frac{b^m}{b^n} = b^{(m-n)}$.

Now in the case of $\frac{b^2}{b^3}$, we have $m=2$ and $n=3$, so we are going to get:

$$\frac{b^2}{b^3} = b^{(2-3)}$$

So, $2 - 3$ isn't 1, is it? It's -1.

Return to Page 101, now, and quit fighting the problem."

The student who elects page 119 will find:

"Page 119

"YOUR ANSWER: The rule won't work in this case.

Courage! The division rule got us through b^0 , where $m=n$, and it will get us through the case where m is smaller than n . In this case we have

$$\frac{b^2}{b^3} = ?$$

and applying the rule

$$\frac{b^m}{b^n} = b^{(m-n)}$$

we get

$$\frac{b^2}{b^3} = b^{(2-3)}$$

So the exponent of our quotient is $(2 - 3)$ which is -1, isn't it?

So just write

$$\frac{b^2}{b^3} = b^{(2-3)} = b^{(-1)}$$

as if you knew what it meant.

Now return to Page 101 and choose the right answer."

And the student who chooses the right answer will find:

"Page 115

"YOUR ANSWER: $\frac{b^2}{b^3} = b^{(-1)}$

NORMAN A. CROWDER

You are correct. Using our rule for division

$$\frac{b^m}{b^n} = b^{(m-n)}$$

in the case of $\frac{b^2}{b^3}$ we get

$$\frac{b^2}{b^3} = b^{(2-3)} = b^{(-1)}$$

Now, by ordinary arithmetic, we can see that

$$\begin{aligned} b^2 &= b \times b = \cancel{b} \times \cancel{b} = ? \\ b^3 &= b \times b \times b = \cancel{b} \times \cancel{b} \times b = ? \end{aligned}$$

So how shall we define $b^{(-1)}$?

ANSWER

$$b^{(-1)} = \frac{0}{b}$$

$$b^{(-1)} = \frac{1}{b}$$

Page

95

104"

The step we have just been discussing would be diagrammed as

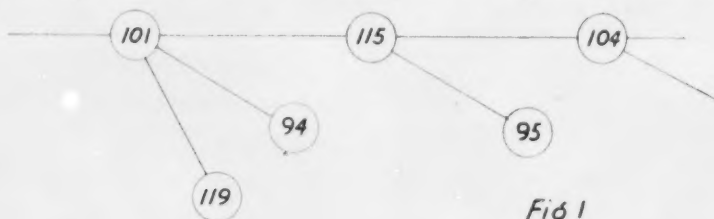


Fig 1

Now, let us suppose that we find, on the basis of actual trial with students, that the explanation given on page 119 is not sufficient. In that case we might re-write the program to add a sub-sequence to begin on a new page 119. We would then write page 119 as follows:

"Page 119

"YOUR ANSWER: The rule won't work in this case.

The rule is

$$\frac{b^m}{b^n} = b^{(m-n)}$$

And the case we are considering is

$$\frac{b^2}{b^3}$$

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Some of the most interesting cases in mathematics occur when we follow a rule beyond the area in which it was developed. The process is risky, but sometimes rewarding. We just reached a definition of b^0 by such a process. So let's forge ahead with the rule in this case and see what happens. In applying the rule, we need only substitute the actual values of the exponents 'm' and 'n' and do the necessary arithmetic. What do we mean by the letters 'm' and 'n' in our division rule?

ANSWER	Page
'm' is the larger exponent, 'n' is	116
the smaller.	
'm' is the exponent of the dividend,	
'n' is the exponent of the divisor.	121"

Page 116 might then read:

"Page 116

"YOUR ANSWER: 'm' is the larger exponent, 'n' is the smaller. Aha! That was the trouble. Up to now, in our discussion of division, m has always been larger (or equal to) n, so you assumed that this was how we decided which letter referred to which exponent. However, in the statement of the rule

$$\frac{b^m}{b^n} = b^{(m-n)}$$

the exponent m is shown to be the exponent of the *dividend* and the exponent n is shown as the exponent of the *divisor*. Now return to page 119 and choose the right answer."

Page 121 will read:

"Page 121

"YOUR ANSWER: 'm' is the exponent of the dividend, 'n' is the exponent of the divisor.

Very well, in the case of

$$\frac{b^2}{b^3}$$

the exponent of the dividend is 2 and the exponent of the divisor is 3, so our rule

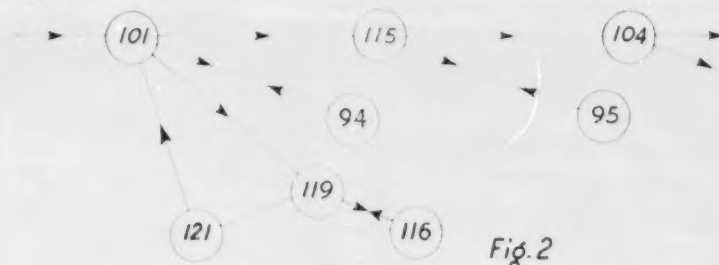
$$\frac{b^m}{b^n} = b^{(m-n)}$$

gives us

$$\frac{b^2}{b^3} = b^{(2-3)}$$

Now finish the arithmetic and then return to Page 101 and choose the right answer to the question on that page."

Our new structure with the sub-sequence would be diagrammed as follows:



Another variation that is frequently useful is one in which a wrong answer returns the student to a previous point in the main sequence, to review the preceding development. Such a sequence would be diagrammed as shown in Figure 3.



The student in this sequence who chooses alternative A in the last step shown is "washed back" two steps in the main sequence.

A variant of the "wash-back" technique is one in which the main sequence of questions is quite difficult and only a few students are expected to get any single answer in the main sequence correct. Those who miss a question in the main sequence are fed to a sub-sequence which takes smaller steps, as shown on page 48:



Fig. 4

This type of sequence has been advocated by A. A. Lumsdaine in private communication with the writer. It differs from the sub-sequence step previously shown in that the sub-sequence terminates in the *next* step in the major sequence, rather than terminating on the page on which the student left the main sequence.

There is literally no end to the types of sequences that can be developed. A rather fanciful one in which the errors for each question are graded in seriousness and wash the student back 0, 1, or 2 steps accordingly is shown in the diagram below.

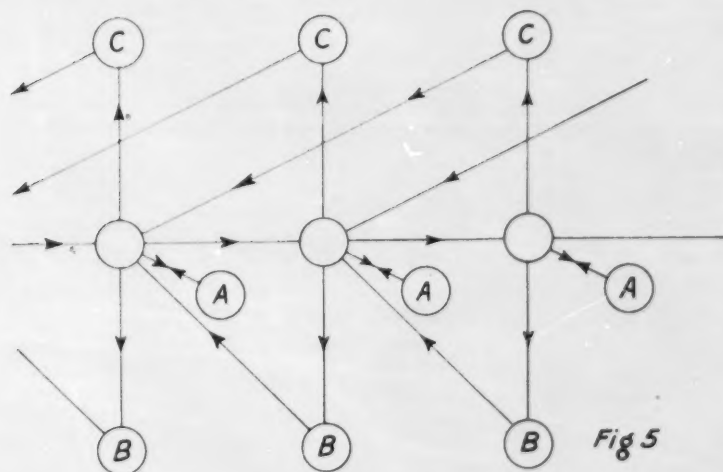


Fig 5

The alternatives marked A represent minor errors, from which the student is referred back to the "current" question page; the B alternatives wash him back 1 step, and the C alternatives 2 steps. (The unmarked circles, of course, represent the right answer pages on which new questions are asked.)

A word of caution is required here. It is an interesting exercise to prepare complex forms of sequences and to reason about their properties and probable consequences. The writer who deals with meaningful material will soon discover, however, that such material has a certain stubborn logic of its own and is not always amenable to our predetermined designs. Communication is, at this stage, more of an art than a science, and the conscientious artist will deal respectfully with his subject matter.

Devices

The principal devices used for automatic tutoring at the present time are the Tutor and the TutorText. Sample TutorText pages have been given in the previous section, in connection with programming techniques, and a 25-page sample sequence from the TutorText "The Arithmetic of Computers" is available. At the outset of the work with TutorTexts, or "scrambled books" as they were originally called, the page numbers were assigned essentially at random, the object being only to prevent the reader from passively scanning the material by not providing a "next page" except as the reader chose an answer to a question. However, as work progressed, it was found that, the order of pages being arbitrary, a number of useful juxtapositions of facing pages could be achieved. The most common example is that of letting a wrong-answer page face the page on which the general discussion of the point in question is given.

TutorTexts have been prepared, or are in preparation, in such diverse fields as algebra, trigonometry, physics, chemistry, law, and contract bridge. A series of such works will be published by Doubleday and Company beginning in the autumn of 1960.

The Western Design Tutor shown in Figure 6 is a complete, recording, automatic tutoring system. The material is handled on 35 mm film and the device has a capacity of 10,000 images, any of which may be called up,

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in any order, by entering the appropriate image number in the keyboard. Motion picture sequences may be freely intermixed with still (microfilm) material, but the film moves only when a motion picture sequence is desired. The 10,000-image capacity is, therefore, adequate for any practical or research purpose.

The student seated at the machine will find the first unit of information on image 0001, and the question will have choices numbered, say, 0007, 0003 and 0011. Electing one of these answers, he enters that image number into the keyboard, presses the VIEW button, and the required image appears. It may present a new item of information and a new question, or correctional material, just as in the TutorText. When it is desired to show motion, the student will be instructed (by the material in the Tutor, of course) to enter a particular image number into the keyboard, as before, but in this case to use the MOTION button instead of the VIEW button to initiate the search cycle. The motion sequence will then be projected automatically and stop at a question on what the student has seen. Since the film can be stopped at any pre-selected image and restarted by the student (following directions that appear on the film) any desired degree of control of a film sequence is possible.

The recorder compiles a record of the sequence of images viewed by the student and the amount of time spent on each. In addition, the image number of the last image viewed appears in the recorder view window. This feature is included so that a student who has inadvertently entered a completely wrong number (i.e., a number not included in the choices provided) and thereby "gets lost," can return to the image he was previously viewing.

The advantages of the Tutor derive from the recording capability, the use of film, and the large information storage capacity. The complete recording allows the material to be developed and tested, and permits an unprecedented degree of administrative control of the teaching situation. The use of film permits motion picture sequences to be used and allows accurate color renditions to be used and allows accurate color renditions to be economically achieved. This latter point is of some importance in such areas as the training of medical technicians. The use of film is, of course, responsible for the 10,000-image storage capacity which allows us to use any reasonable branching program and still have plenty of space left for motion sequences.

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Figure 6

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Summary

To sum up what has been said, we approach the design of a teaching machine as a problem in communication. The conditions of the program are such that the greatest flexibility, both within and between program steps, is required. The within-steps flexibility is required because we wish to communicate complex information to a complex organism, that is, an intelligent human being. To provide the necessary flexibility within steps the devices provide that any unit of information up to the amount that can be presented on a single page or a page size viewing screen can be presented at a single presentation. The requirement for flexibility between steps arises because communication may fail, particularly if we are attempting to get the student to flex his mental muscles a little and give him fairly stiff questions. The required flexibility is achieved by the use of the intrinsic programming technique, in either the TutorText or the Tutor.

REFERENCE

1. GUSTAVE J. RATH, NANCY S. ANDERSON, R. C. BRAINERD. The IBM Research Center Teaching Machine Project. *Automated Teaching: The State of the Art*, edited by Eugene Galanter. John Wiley and Sons, 1959.

Teaching Machines: An Application of Principles from the Laboratory

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Much has been said of teaching machines recently—but the emphasis has tended to be on the gadgets rather than on the much more significant development of a new technology of education initiated by B. F. Skinner (1). The technology does use a device called a teaching machine which presents a finely graded series of problems and provides immediate “reward” or reinforcement for the student’s correct answers. But emphasis on machines has tended to obscure the more important facets of the new technology based on application of principles from the laboratory. The machines of today are not necessarily better than those of yesterday. Indeed, adequate machines could have been built hundreds of years ago. The movement today is not simply the mechanization of teaching, but instead the development of a new technology—a behavioral engineering of teaching procedures.

The history of unsuccessful teaching machines illustrates the relatively greater importance of the technique as opposed to the gadgets. The first teaching machine was patented 93 years ago. There have since been a series of patents and a promising burst of activity by Sidney Pressey and his associates (2) in the 1920’s. None of these early efforts really caught hold. But during this period in which the idea of mechanized teaching has been latent the science of behavior has developed principles which permit extremely precise control of behavior. This new technology is not only the so-called automation of teaching but is an attempt to obtain the kind of behavioral control shown possible in the laboratory.

We have, of course, seen other practical applications of scientific psychology. We are all familiar with the development of a technology of testing which permits placing an individual in situations suited to his

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abilities. We are also familiar with another technology called human engineering, which fits machines and jobs to the capacities of man. One places a man in a job that suits him; the other alters the job to suit the man; *neither* attempts to alter or control man's behavior.

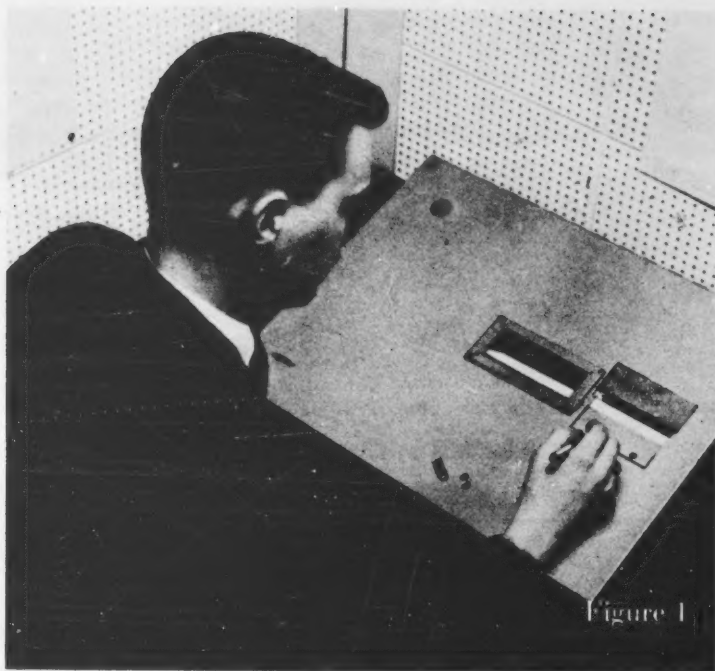
For years in the laboratory we *have* controlled the behavior of experimental subjects—both animal and human—by a widening array of principles and techniques. The new technology of education is the application of behavioral laws in modifying or controlling behavior. Such a technology became possible with the realization that we are actually referring to a verbal repertoire (3) controlled by the same laws as other behavior. The old, defunct explanatory concepts of knowledge, meaning, mind or symbolic processes have never offered the possibility of manipulation or control; but behavior, verbal or otherwise, can be controlled with ease and precision.

While machines are not the essential or defining aspect of this technology, they do play an important role in providing some of this fine control the technology requires. We will now examine several machines and notice the advantages they offer.

At Harvard there is a self-instruction room with ten booths, each containing a machine like the one shown in Figure 1. The student gets one set of material from the attendant and places it in the machine. He closes the machine and begins his studies.

This machine presents one item of material at a time. The subject reads the statement which has one or more words missing and he completes the statement by writing in the answer space. He then raises the lever and a small shutter opens revealing the correct answer, and simultaneously his answer is moved under glass where it can be read and compared with the now-exposed correct answer. After comparing his answer with the correct answer the student indicates to the machine, with an appropriate movement of the lever, whether his answer was correct or incorrect and the next item appears in the window. All items answered wrong are repeated after he completes the set of items. Correctly answered items are not repeated.

A critical feature of the machine is that it provides immediate reinforcement for correct answers. Being correct is known to be a reinforcer for humans (4). In machine teaching reinforcement is immediate. We know from laboratory work that a delay between a response and its reinforcement of a few seconds will greatly reduce the effectiveness of



the reinforcement. Adult humans have developed behavior which serves to mediate small delays; nevertheless, any delay makes reinforcement less effective.

Although other techniques such as programmed workbooks (5), "self-correcting" homework (6), and flashcards are sometimes used in this new behavioral technology, they offer less control. Teaching machines eliminate undesirable forms of responses which would also be successful in obtaining the right answer. For example, the teaching machine insures that the student answer before peeking at the indicated answer. There is a strong temptation to glance ahead with only a poorly formulated, un-written answer when flashcards are used.

This write-in machine is a prototype of the most common machine. There is another machine used for teaching young children material which consistently has a single possible answer. In the machine the constructed answer is automatically compared with the true answer.



The child is presented a problem, perhaps a statement such as $2 + 2 = \underline{\quad}$, and he must provide the "4". By moving a slider appropriately he can insert the 4 into the answer space. He then turns the crank, and the next item appears immediately, and therefore, immediate reinforcement is provided.

Both of the machines described thus far require the student to compose the answer. Figure 2 shows a machine for a less mature organism who cannot yet compose an answer. This machine can be used for teaching preschool children (7). There is a large top window and three small windows. In the large window there is some sort of problem, and in the three smaller windows, there are three alternative choices. For example, in the machine as seen in the picture, the subject chooses one of the three alternatives which has the same form as the sample, independent, in this case, of color or size. When the correct choice is made, the next frame is presented.

A teaching machine for a still lower organism is shown in Figure 3. The pigeon in the picture, with the aid of a teaching machine, has learned to hit the name plaque appropriate for a color projected above him. The principal difference between this and the other machines is that food reinforcement is used. With humans, simply being correct is sufficient

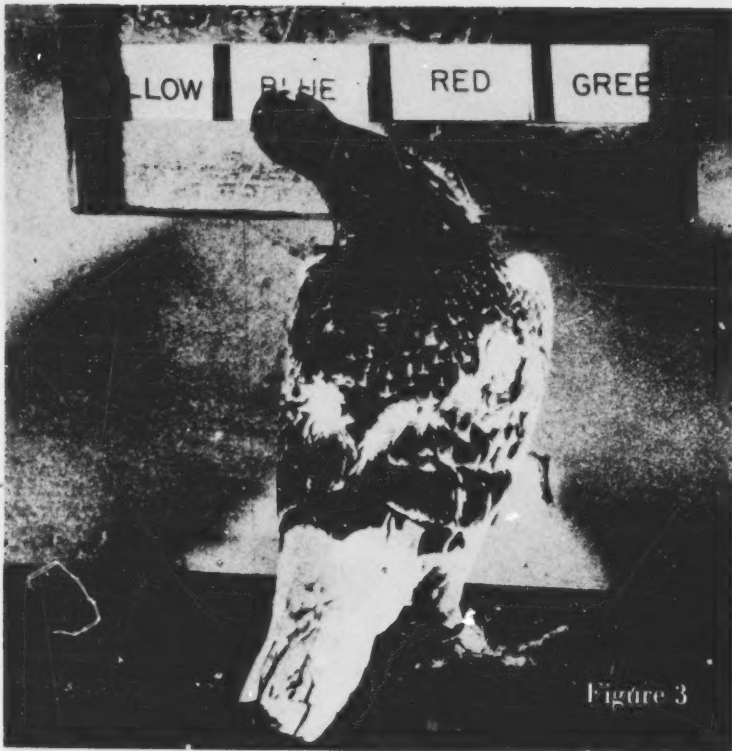


Figure 3

reinforcement --pigeons will not work for such meager gains.

Enough of machines. They should not be allowed to obscure the truly important feature of the new technology, namely, the application of methods for behavioral control in developing programs for teaching. We need to say no more about the well-known principle of immediate reinforcement. Our second principle is also well known. Behavior is learned only when it is *emitted* and reinforced. But in the classroom, the student performs very little, verbally. However, while working with a machine, the student necessarily emits appropriate behavior and this behavior is usually reinforced since the material is designed so that the student is usually correct. Not only is reinforcement needed for learning, a high density of correct items is necessary because material which generates errors is punishing. Laboratory experiments (8) have shown

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that punishment lowers the rate of the punished behavior. In our experience with teaching machines we have also observed that students stop work when the material is so difficult that they make many errors. Furthermore, they become irritated, almost aggressive, when errors are made.

The third important principle is that of gradual progression to establish complex repertoires. A visitor once asked if Skinner had realized that pigeons were so smart before he began using them as subjects. The answer given by a helpful graduate student was that they weren't so smart before Skinner began using them. And indeed they weren't. The behavior developed in many experiments is like that developed in the classroom. Both are complex operants. Both require a careful program of gradual progression. We cannot wait for a student to describe the content of a psychology course and then reinforce the performance; nor can we wait for a pigeon to emit such an improbable bit of behavior as turning a circle, facing a disk on the wall, pecking it if lit, and then bending down to a new exposed food tray and eating.

When developing a complex performance in a pigeon, we may first reinforce simply the behavior of approaching the food tray when it is presented with a loud click. Later the pigeon learns to peck a key which produces the click and the food tray. Still later, he may learn to peck this key only when it is lit, the peck being followed by the loud click and approach to the food tray. In the next step, he may learn to raise his head or hop from one foot to another, or walk a figure eight, in order to produce the lighted key which he then pecks; the click follows; and he approaches the food tray.

This principle of gradual progression runs through many of the teaching machine techniques. Both human and avian scholars deserve the same careful tutorage. The teaching machine program moves in very finely graded steps, working from simple to an ever higher level of complexity. Such a gradual development is illustrated in Table 1 by a few items taken from a psychology program (9).

The principle of gradual progression serves not simply to make the student correct as often as possible, but it is also the fastest way to develop a complex repertoire. In fact, a new complex operant may never appear except through separately reinforcing members of a graded series (10). Only this way can we quickly create a *new pattern* of behavior. The pigeon would not have learned the complex sequence necessary to

receive the food if he had not learned each step in its proper order. Obviously a child can't begin with advanced mathematics, but neither can he begin with $2 + 2 = 4$ —even this is too complex and requires a gradual progression.

Our fourth principle is, in a sense, another form of gradual progression—one which involves the gradual withdrawal of stimulus support. This we shall call fading. This method will be illustrated with some neuroanatomy material (11). In Figure 4A is a fully labelled cross section of the medulla oblongata. This is placed before the student while he works with a large set of items pertaining to the spatial arrangement of the various structures. For example, "posterior to the cuneate nuclei are the _____." The answer is: "the cuneate fasciculi."

After many such items, he begins another set and has another picture (Figure 4B) before him, but now the structures are only labelled with initials. A new set of items again asks a long series of questions pertaining to the spatial position of the various structures. For example, "between the gracile and the trigeminal nuclei are _____." The answer is the "cuneate nuclei."

After many more items, he proceeds to a new set and the next picture. This time (Figure 4C) the picture is unlabelled. Again, he goes through a series of new items, not simple repetition of the previous ones, but pertaining to the same program of the spatial location of the different structures. This set is followed by still another, but with no picture at all. He is now able to discuss the spatial position of the structures without any visual representations of the structures before him. In a sense, he has his own private map of the medulla. He may further demonstrate his newly acquired ability by accurately drawing the medulla.

The neuroanatomy example is an elaborate example of fading. Fading is also applied in a more simple form in constructing verbal programs without pictorial displays. A single item may in one sentence give a definition or a general law and a second sentence in that same item an example in which a key word is omitted. This would be followed by a new example in the next frame, but with the definition or law lacking.

This brings us to our fifth principle, control of the student's observing and echoic behavior. In the classroom the student is often treated as though he were some kind of passive receiver of information who can sop up information spoken by the teacher, written on the blackboard, or presented by films. But all of these are effective only insofar as the stu-

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Table 1. Items from the psychology program (9). These items illustrate the gradual development of a new concept.

Item	Correct Answer	Percentage of Students Giving the Answer
1. Performing animals are sometimes trained with "rewards." The behavior of a hungry animal can be "rewarded" with _____.	Food	96
2. A technical term for "reward" is reinforcement. To "reward" an organism with food is to _____ it with food.	Reinforce	100
3. <i>Technically</i> speaking, a thirsty organism can be _____ with water.	Reinforced	100

50. A school teacher is likely, whenever possible, to dismiss a class when her students are rowdy because she has been _____ by elimination of the stimuli arising from a rowdy class.	Reinforced	92
51. The teacher who dismisses a class when it is rowdy causes the frequency of future rowdy behavior to (1) _____, since dismissal from class is probably a(n) (2) _____ for rowdy children.	(1) Increase (2) Reinforcement	86

54. If an airplane spotter never sees the kind of plane he is to spot, his frequency of scanning the sky (1) _____. In other words his "looking" behavior is (2) _____.	(1) Decreases (2) Extinguished (or: Not Reinforced)	94

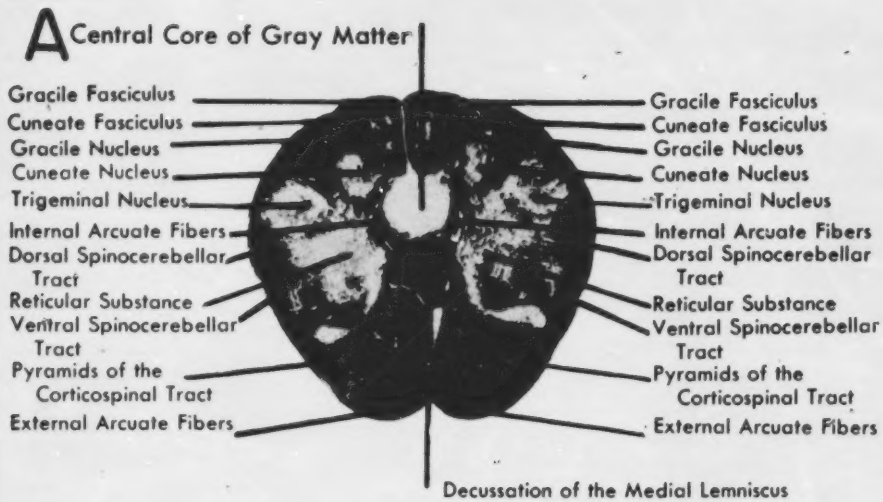


Figure 4

The diagrams above illustrate the technique of fading. Figure 4A is in front of the student as he works on the earliest items of a neuroanatomy program; 4B is in front of him for later items; 4C for still later items.

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dent has some behavior with respect to the material. He must listen carefully, or read carefully, thus engaging in usually covert echoic behavior.

Ineffectiveness of classroom techniques is often credited to "inattention" or poor "concentration." It has been shown (12) that if a discrimination is to be learned, adequate observing behavior must first be established. We have further found (13) that observing behavior, or, speaking loosely, "attention" is subject to the same forms of control as other behavior. This control of observing behavior is of prime importance. When the student becomes very "inattentive" in the classroom, the teaching material flows on; but with a machine, he moves ahead only as he finishes an item. Lapses in active participation result in nothing more than the machine sitting idle until the student continues.

There is, however, a more subtle aspect to the control of observing behavior than this obvious mechanical one. In many of the examples we have seen, success in answering the problem only depends on the student's careful observation of the material in front of him at the moment. This may be illustrated by more material from the psychology program. A graph showing stimulus generalization data is in front of the student while he works on the machine. In the program he may complete a statement like the following: "As the wave length changes in either direction from the wave length present during reinforcement, the number of responses _____." The answer is "decreases." The item serves only to control the behavior of observing the data. Of course, many more such items are used to discuss the same data.

This principle of controlled observation extends to the details of writing a single item. For example, "Two events may have a common effect. An operant reinforced with two reinforcers appropriate to different deprivations will vary with _____ deprivations." The answer is "two" or "both." Here the programmer's choice of the omission serves to insure a careful reading of the item. *Only* those parts of an item which must be read to correctly complete a blank can safely be assumed to be learned.

Our sixth principle deals with discrimination training. In learning spoken languages, for example, it is necessary to be able to identify the speech sounds. A student may listen to a pair of words on a special phonograph which repeats the passage as many times as he desires. The visual write-in machine instructs him to listen to a specific passage.

For example, the student may hear two words such as: "sit, set." He listens as many times as he needs, then writes the phonetic symbols in the write-in machine and operates the machine, thereby exposing the true answer and providing immediate reinforcement for his correct discrimination.

However, little academic education is *simple* discrimination. More often, it is abstraction or concept formation. An abstraction is a response to a single isolated property of a stimulus. Such a property cannot exist alone. Redness is an abstraction. Anything that is red has other properties as well—size, shape, position in space, to name a few. There are red balls, red cars, red walls. The term "red" applies to all of them but not to green balls, blue cars, or yellow walls. To establish an abstraction (14), we must provide many examples; each must have the common property, but among the various examples there must be a wide range of other properties. This is best illustrated by examples from the preverbal machine shown in Figure 5.

These are from a program (15) which teaches a child to respond to the abstract property of form. In each item, the upper figure is the sample and the lower three are the alternatives. While developing a program for establishing an abstraction we remember our earlier principles, and move through a gradual progression. The first several items would be like the first one; here there is a sample and a single match, the other two being blank. The sample and its match are exactly alike at this stage.

After many such items, we would begin to have others like the next one in which the sample and its match again correspond in size, color and form, but an additional incorrect alternative has been added which differs from the sample in all these aspects. Later we move on to frames with three choices, again the sample and its match corresponding exactly. Next, the sample and the match may differ in some property such as color, in the case of the next item shown, or size in the next. It is essential that the program contain many items among which the sample and correct match differ in all properties except the one providing the basis for the abstraction. Otherwise the abstraction will be incomplete because the extraneous property will share some of the control over the abstract response.

As we move on with additional examples, the sample and the correct match differ both in color and in size, and the incorrect alternatives are beginning to share some of the extraneous properties with the sample.

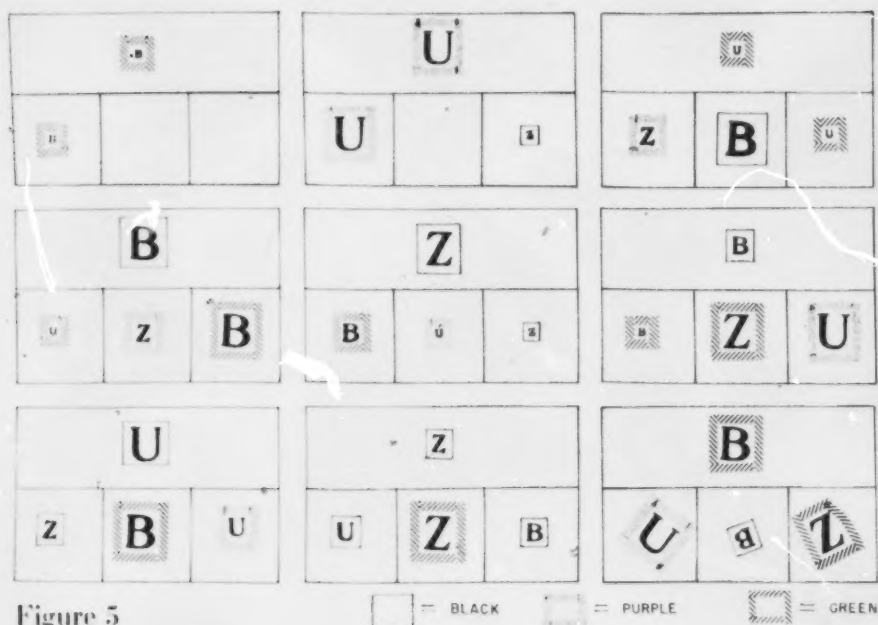


Figure 5

These are selected items from a program that teaches young children to respond in terms of the abstract property of form. The upper rectangle in each frame is the sample. The child must choose the alternative that corresponds to the sample in form. The color of each letter, as it would appear in the actual program, is indicated here by various shaded areas.

The student continues with many such problems in which the only common property between the sample and the correct match is the shape, regardless of size and color. Even now our abstraction may be incomplete. We have kept the figures in only one orientation. Therefore, we also have a series in which the samples are rotated as in the next item.

A great deal of academic education consists of trying to teach abstractions. Concepts such as force, reinforcement, supply-and-demand, freedom, and many, many other possible examples are all abstractions. Furthermore, in the academic setting, the student seldom adequately forms abstractions. The trigonometry student commonly uses triangles with the right angle as one of the two lower angles. If the triangle is

rotated 90° , so that the right angle is upward, the student often does not recognize it as a right triangle. Neither is an abstraction developed simply by learning a definition. The psychology student who learns the definition of reinforcement in formal terms and is acquainted with a laboratory example of food reinforcement, may not realize the horrible consequences of sending his girl friend flowers to end an argument. Thus, in the psychology program, to develop a new concept, we follow the pattern in the preverbal example. A wide range of examples are analyzed which differ in as many aspects as possible, each still having the common property which characterizes the concept.

The last principle I shall discuss is really a question of methodology which has served so well in the laboratory. This principle is to let the student write the program. A few years ago, the cartoon shown in Figure 6 was published in the *Columbia Jester*. The rat leaning on the bar is saying to the other rat: "Boy, do we have this guy conditioned. Every time I press the bar down, he drops a pellet in."

Although said in jest, it is true that the rat controls the experimenter's behavior. When interesting things are observed about the rat's behavior, the control circuits are rewired to investigate the interesting new facet of behavior. In a sense, the rat is wiring the control circuit. Similarly, the behavioral engineer who prepares good teaching machine material must be under the control of the student's responses. When the student has trouble with part of a program the programmer must correct this. The student's answers reveal ambiguities in items; they reveal gaps in the program and erroneous assumptions as to the student's background. The answers will show when the program is progressing too rapidly, when additional prompts are necessary, or when the programmer should try new techniques. When unexpected errors are made, they indicate deficiencies *not* in the student but in the program.

Figure 6



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The most extensive experience with this principle of modifying the program to fit the student has been at Harvard (16) with the psychology program. In 1958, we had a program consisting of forty-eight disks or lessons of twenty-nine frames each. After using the program and making a detailed, item-by-item analysis of the students' answers we diagnosed the particular deficiencies in the program and revised it accordingly. The program was also extended to cover a larger amount of subject matter and, in 1959, it consisted of sixty disks. You have already seen a few items from the course. After using the revised material in 1959, we evaluated the extent of its improvement. Table 2 shows the percentage of errors on the first twenty disks for each of the two years.

Table 2. A comparison of the student's errors in using the revised (1959) and unrevised (1958) program in psychology.

	Percent Errors	Percent Items Improperly Scored by Students
1958	20.1	3.6
1959	11.0	1.4

The revision eliminated about half the errors. The last column of the table gives percentage of improper self-scoring by the students. Revision also cut these scoring errors approximately in half. Furthermore, the revision decreased the time required to complete the material. Although the second year's material had more disks—sixty as opposed to forty-eight—it actually required the average student about one hour less to complete the work than it had required for the shorter first version. Frequency distributions on the median times in minutes for completion of the various disks are shown in Figure 7. These are the times required for the median student to move through each set of material answering every item once and to repeat the items answered incorrectly. Notice the considerable time required for many disks in the first year's material. Primarily this was because students repeated the larger number of items missed in the first cycle.

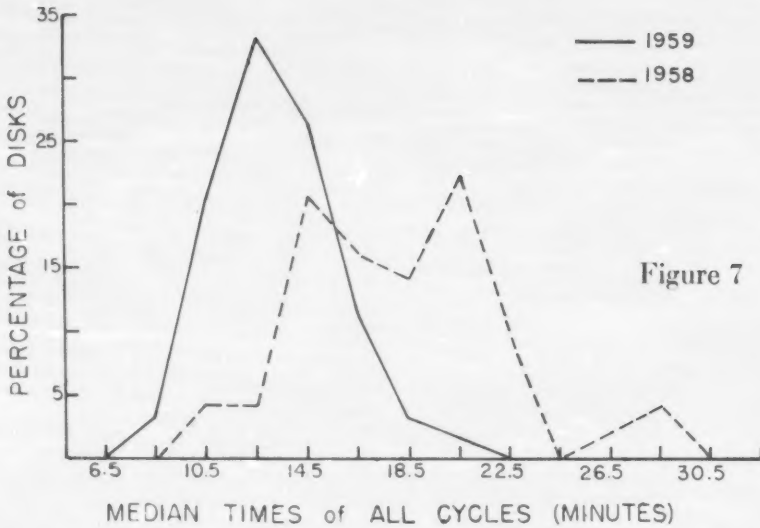


Figure 7

Here are the frequency distributions for the median times to complete disks or "lessons" for the revised and unrevised psychology program. Raw frequencies were converted to percentages to equate the area under the curves.

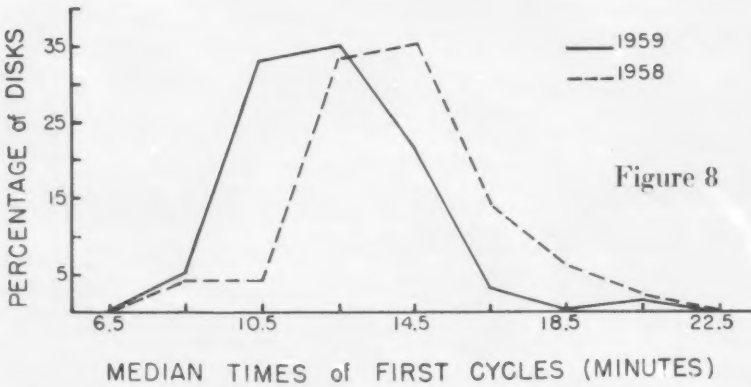


Figure 8

Here are the frequency distributions for the median times to complete only the first cycles for the revised and unrevised psychology program. Raw frequencies were converted to percentages to equate area under the curves.

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But the improved material provided faster performance, even when the delay due to repetition of incorrectly answered items is not considered. The frequency distributions for the first cycle only are provided in Figure 8. These data exclude the time used in repeating items. Here too the revision produced slightly more rapid progress.

Such careful tailoring of material to fit the student is impossible with most teaching techniques. With teaching machines, as in no other teaching technique, the programmer is able to revise his material in view of the students' particular difficulties. The student can write the program; he cannot write the textbook.

We have seen that the principles evolved from the laboratory study of behavior have provided the possibility for the behavioral engineering of teaching. This new technology is thoroughly grounded in some of the better established facts of behavioral control. The future of education is bright if persons who prepare teaching machine programs appreciate this, and appropriately educate themselves in a special, but truly *not* esoteric, discipline. But it is vital that we continue to apply these techniques in preparing programs. The ill-advised efforts of some of our friends, who automatize their courses without adopting the new technology, have an extremely good chance of burying the whole movement in an avalanche of teaching-machine tapes.

REFERENCES

1. B. F. SKINNER. The science of learning and the art of teaching. *Harvard Ed. Rev.*, 1954, 29, 86-97; B. F. SKINNER. Teaching machines. *Science*, 1958, 128, 969-977.
2. S. L. PRESSEY. Simple apparatus which gives tests and scores and teaches. *School and Society*, 1926, 23, 373-376.
3. B. F. SKINNER. *Verbal Behavior*. New York: Appleton-Century-Crofts, 1957.
4. C. T. PERIN. The effect of delayed reinforcement upon the differentiation of bar responses in white rats. *J. Exptl. Psychol.*, 1943, 32, 95-109.
5. L. E. HOMME AND R. GLASER. Relationship between the programmed textbook and teaching machines. Paper presented at the Conference on Automatic Teaching of Verbal and Symbolic Skills, 1958.
6. P. B. DIEDERICH. Self-correcting homework in English. *Proceedings of the 1959 Invitational Conference on Testing Problems*. Princeton: ETS, 1960.
7. W. HIVELY. Exploratory investigation of a teaching machine for visual discrimination. (In preparation.)
8. N. H. AZRIN. Some effects of two intermittent schedules of immediate and non-immediate punishment. *J. Psychol.*, 1956, 42, 3-21.
9. J. G. HOLLAND AND B. F. SKINNER. A self-tutoring introduction to a science of behavior. Unpublished manuscript; copies available.
10. F. S. KELLER AND W. N. SCHOENFELD. *Principles of Psychology*. New York: Appleton-Century-Crofts, 1950.
11. This material has been prepared by D. M. Brethower in collaboration with the present author and is being used at Harvard for research purposes.

JAMES G. HOLLAND

12. L. S. REID. The development of noncontinuity behavior through continuity learning. *J. Exptl. Psychol.*, 1953, 46, 107-112; L. B. WYCKOFF. The role of observing responses in discrimination learning. *Psychol. Rev.*, 1952, 59, 431-442.
13. J. G. HOLLAND. Human vigilance. *Science*, 1958, 128, 61-67.
14. C. I. HOVLAND. A set of flower designs for experiments in concept formation. *Amer. J. Psychol.*, 1953, 66, 140-142; C. I. HOVLAND. A "communication analysis" of concept learning. *Psychol. Rev.*, 1952, 59, 461-472.
15. This program was prepared by B. F. Skinner.
16. J. G. HOLLAND. Teaching psychology by a teaching-machine program. Paper presented at the 1959 meeting of the American Psychological Association.

Self-Correcting Homework in English

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My assignment is to close the conference with a report on what ETS has done, is doing, and hopes to do about the instructional use of self-correcting exercises in the form of tests. Samples of our kinds of exercises are now being distributed. They will also appear in the Proceedings of this conference. (Ed. note: See pages immediately following this paper.)

You already have the kind of "teaching machine" that our clients are using. It is the conference program or any other scrap of paper or cardboard that you can place below the item on which you are working to cover up the correct answer until you have given your own. It is not as expensive as Crowder's machine or Skinner's, and it will not do as many things as their machines will do, but a great point in its favor is that you have it right now and can carry it around with you.

That point is essential in our system since all of our exercises are designed to be used as homework assignments, and about five hundred pages of them are being used in that fashion this year. Hence the device that is used to cover up the correct answers and then to reveal them as soon as the student has given his own must be, above all things, portable, cheap, and immediately available. We get around the problem of cheating in a different way, which I shall presently explain.

The first of our sample exercises is on a poem that I discussed in this conference two years ago to illustrate techniques of item-writing in the humanities. I thought you might enjoy seeing how the same techniques can be applied in an exercise that is designed to show students how to read a difficult poem rather than to test how well they already know how to read one. Such an exercise would normally follow a class discussion of the poem and would be used as a homework assignment to make sure that everyone understood what the poem meant, and in the process acquired some skill in figuring out the meaning of the next poem that the class was to study. The objective is not merely to understand this par-

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ticular poem but to pick up a method of dealing with poems that are a bit difficult to understand at first sight.

To find out how our exercises work, place your program, or anything else that is handy, just below the first item. You are supposed to write your answer in the parenthesis at the end of this item. Then move your program down below item 2. The number in parentheses at the beginning of item 2 is the intended answer for item 1. If the number you wrote does not agree with this key, you are supposed to encircle the parenthesis or mark it with a big, fat X to signify that you got it wrong. After you finish the exercise, you are supposed to re-study all the items that you got wrong, and if you still do not understand why your answers were wrong, or do not agree that they were wrong, you are to mark them with a question mark or exclamation point so that you can take them up with the teacher the following morning before she gives you the short test that appears after each exercise.

Students will not have access to this test while they are working on the exercise. They will see it for the first time the following morning, when it will be given under test conditions in class. You will notice that the test does not have the intended answers anywhere in sight. Students will mark their answers as they mark any short classroom test, usually during the first ten minutes of the following day in the same class. When they finish, the teacher will collect the papers, shuffle them, and pass them back in random order, making sure that no student receives his own paper. She will then read the intended answers aloud while each student scores the paper that he is holding. Whenever he marks an item "wrong," he is to hold up his hand. The teacher will count and record the number of hands opposite each item on her copy of the test. Then she will conduct a discussion of the items that more than 10% of the class missed, usually by asking students who chose some other answer to defend their answer, and students who disagree to prove to them that they were wrong. The teacher will present arguments and explanations of her own only as a last resort. Learning takes place at this level chiefly by having students argue out these points with one another.

Students will get no credit for their score on the exercise but only for *their* score on the test, which will usually be only a small sample of the material covered in the exercise. It is a standing rule with us that no point covered in the exercise shall ever reappear in anything like the same words in the test. Hence students cannot simply memorize the

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words; they have to grasp and remember the ideas and be prepared to transfer them to new material in the test. This is probably the reason why no teacher has thus far reported any problem of cheating on the exercises. There is no point in doing so, since the teacher does not even ask the students how they made out. Instead, they ask her, if necessary, why in blazes the answer to item 13 was supposed to be 3, when to their way of thinking it was obviously 2. Doing the exercises honestly is simply the quickest, easiest, and most interesting way to prepare for the tests. The tests do count in the record and have their appropriate weight in determining the student's grade.

I hope that it is now clear how these exercises are used in conjunction with class work, and that every exercise will be backed up by class discussion of any points that more than 10% of the class failed to understand. Thus the class does what Crowder's machine does automatically when any of his students choose a wrong answer. We do not have a mechanical device comparable to Skinner's that gives the students a second shot at the items they missed on the first round, but they mark these answers "wrong" and re-study them before the test to make sure that, if these points come up in the test in different words and a different context, they will then get the answers right.

Notice that all of our exercises can be run off on any Ditto or Mimeograph machine; they do not require more expensive forms of presentation that are not readily available to teachers, such as disks, tape, or films. That is because we are doing our whole exploration of the possibilities of self-correcting exercises in the form of tests through cooperation with selected teachers of English in grades ten through twelve.

We got eighty-eight such teachers together last summer in two workshops, one of which was handsomely supported by the Fund for the Advancement of Education, so that we could go out and get the teachers we wanted and pay them to attend. We interested them in this new medium of instruction, showed them various forms of self-correcting exercises, and asked them what parts of their work, if any, they would like to present in this way. There was no compulsion to produce exercises at all, since we provided plenty of other things to do, but on their own initiative they produced about five thousand usable items in the fields of reading comprehension, vocabulary, choice of words to fill in blanks in well-written paragraphs, grammar, punctuation, spelling, sentence formation, and paragraph development. There was very little duplication

of effort, since we outlined the field in advance and each teacher staked out a claim for the portions he intended to cover.

I taught them a simple procedure for classroom item-analysis by a show of hands, and I shall consider for publication only one copy of each exercise that has the specified figures written on it with suggestions for revision. Each contributor duplicates his own exercises at the expense of his school, and is trying them out in his own classes and, if possible, in the classes of at least one other teacher. All of this work is being carried on without any subsidy and without any hope of monetary return, simply because these teachers wanted to present some parts of their work in this way, and hope ultimately to benefit by similar exercises prepared by other teachers. They believe that these exercises will make life easier for them, and will clear up the problems they deal with once and for all.

That was the first thing we wanted to find out: whether good high school English teachers want to adapt parts of their work to these exercises, what parts, and whether they cared enough about it to produce exercises on their own, have them duplicated at the expense of their schools, and try them out in their own classes. The answer is that they do, and we now know the areas in which they see possibilities and the forms of exercises that they themselves devised to do the things they wanted. We have to be careful about such considerations because it is a standing rule at ETS to avoid any suspicion of attempting to dominate the curriculum. Our skirts are now entirely clear. We can say of all the exercises now undergoing tryout that these are the things good English teachers now want to do with programmed exercises; these are the forms of exercises that they themselves developed; and the results of their own tryout, item-analysis, and revision will be submitted to us in the course of the year.

I do not see how one could conduct a program of development in a new field like this with less imposition of our own views. Later on, of course, we shall have to edit, touch up, and fill in gaps, but only after we see what promising lines of development emerge from the thinking and experimenting of a large number of good high school teachers.

The next thing to notice about this outpouring of items is a startling change in the order of magnitude of potential use of test items. I can best illustrate this point by comparing the number of instructional items now being tried out with the number of items in the new Cooperative STEP

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tests in English for the same three grades. There are three tests: reading comprehension, listening comprehension, and writing ability, and each test takes two class periods. People thought we were crazy to require so much testing time in a single subject, but the complete battery includes just 202 items. If students are retested on parallel forms (which will happen in relatively few schools), they will be exposed to a grand total of 404 test items in these three years. People in high places are already complaining that answering so many test items in senior high school will leave students no time or incentive to write any papers, and that teachers will have practically no time left in which to teach.

By contrast, when we asked a large number of good teachers what parts of their work they thought they could teach better by means of test items, they produced over five thousand items in a single summer and are now happily trying them out at their own expense, without any compulsion or exhortation. At that, we have barely scratched the surface. These teachers left the workshops declaring that they had only begun to learn how to write good items for instructional purposes, and promising to produce additional exercises in designated areas throughout the coming year.

I expect at least one more round of workshops and a round of controlled experiments next year before we release anything for general use, but it is my own private goal, not necessarily shared by ETS, that we shall be able to publish five paperback booklets of exercises, averaging about 200 pages in length, by the fall of 1961, or, at the latest, by the fall of 1962. If we do, I expect them to sell like hotcakes, for whenever I explain these exercises to groups of high school English teachers and show them samples, the one question that is sure to be asked is "How soon can we get them?"

I hope that we shall have a few years to play with this new toy without much restriction as to time until teachers find out by direct experience what it can do and what it can't do. In our own thinking, however, we have set a definite target date by which time we hope to establish the convention that it is unprofessional to use one of these exercises as homework for an entire class more often than once a week. We do not want them to be used like workbooks to fill up a period whenever the teacher can think of nothing else to do.

The target date is 1965, chosen because most English teachers will then be meeting about 200 students a day in five classes, and about a quarter

to a third of their graduates will be unable to get into college or will be flunked out during the freshman year on the ground that they cannot read or write at the level required by college work. Then the situation will be desperate enough to force drastic action. Although our ideas may change by that time, we agreed last summer on an emergency program to adopt when the teaching load becomes so heavy and college rejections so numerous that both teachers and taxpayers will realize that the traditional five periods a week of English, taught by a single teacher, cannot go on any longer.

When that time comes, we hope to break up every unteachable class of forty or more students into two teachable sections of twenty to twenty-five. Each section will meet with the English teacher only two days a week: one day for the discussion of books that have been read in common, the other for the discussion of student papers. During these two days, the other section will go to a large "free reading room," probably in a temporary building, conducted by a team of college-educated housewives with a lively interest in books and in young people, who will be on duty not more than three hours a day at two to three dollars an hour. On two other days of the week, these two sections will trade places: those who have met with the English teacher will go to "free reading," and those who have had their "free reading" and have checked out books to read at home will meet with the English teacher for the discussion of books and of student papers.

On the fifth day of the week, both sections will report to a room that we trust will be called "The Skinner Room" for a test on the self-correcting homework assigned for that week and class discussion of items that gave the most trouble in the test. We see no reason why this period cannot be conducted by a different set of college-educated housewives, also on part-time duty at two to three dollars an hour, who have been tested for their knowledge of what people like to call the "fundamentals." The readers we hired last year to assist high school English teachers in grading and correcting papers either knew these "fundamentals" extremely well or were soon replaced by someone who did.

While self-correcting exercises in English may take on other functions in the years to come, for the present we expect them to be chiefly concerned with mastery of these "fundamentals." Let me repeat the areas in which most of our eighty-eight teachers chose to work last summer: reading comprehension, vocabulary, choice of words to fill in

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blanks in well-written paragraphs, grammar, punctuation, spelling, sentence formation, and paragraph development. These are "fundamentals." There is no mystery about them, and they are not hard to teach with the aid of self-correcting exercises programmed by experts. In fact, it would be hard to think of an easier task for a beginning part-time teacher than to give a short, ready-made test on the material assigned for the week, to find out by a show of hands how many students missed each question, and then to conduct a discussion of the harder questions by getting the students to argue out these points with one another.

You may wonder why we do not leave this one day a week on "fundamentals" in the hands of professional teachers. The reason is that we can easily find college-educated housewives who are competent to handle these routine parts of English instruction and who will be glad to do it part-time for two or three dollars an hour. The professional teachers, who will be worth their weight in gold in 1965, must save this day for a higher function: namely, conferences with students who are either so far ahead or so far behind that they require individual attention. You must realize that by 1965 most high school English teachers will be responsible for the development in English of about 200 students. All contact of teachers with individual students is likely to be lost unless we do something drastic about it. Part of this drastic action will be the breaking up of huge classes into two teachable sections of twenty to twenty-five students who will meet with the English teacher just two days a week. The other part will be to keep the English teacher free of all class duties one day a week so that he can see students who need special help. The rest will go to the "Skinner Room," take their test, and discuss the items that gave trouble. The few who miss the Skinner period can easily make it up during a free period, since the same test and discussion will ordinarily be offered to at least six different groups by the part-time teachers.

Now perhaps you can see why good English teachers have been so highly motivated to produce self-correcting homework in English. Unless we can prove to the satisfaction of school boards all over the country that such exercises, even in the hands of college-educated housewives, can teach the "fundamentals" as well as or better than they are now being taught in regular English classes, we see no escape from the daily round of five classes a day with forty or more students in each class.

That is a load that even a Roman galley-slave would regard as cruel and inhuman. On the other hand, once we get these "fundamentals" out of our hair, we shall never meet more than twenty-five students at a time except by our own choice, and we shall have one day a week completely free of class duties to talk with individuals who need special help.

We have shown that this will cost no more than it would cost to hire enough additional teachers to maintain even the present shocking level of class size, and by 1965 the additional teachers will not be available. The ETS "Lay Reader Study" revealed an abundance of talent in the average community to handle the three tasks that we have delegated to college-educated housewives: the reader, the free reading aide, and the technician to follow up work on the exercises. The only remaining hurdle is to provide abundant material for the exercises and to prove that they will do the job.

In conclusion, I should like to comment on certain differences between our approach to this problem and the approaches discussed by Mr. Crowder and Mr. Holland. First, we do not use any machinery, and our exercises can all be printed in ordinary paperback booklets or duplicated on Ditto or Mimeograph machines. We do not think any special equipment is necessary, since we handle the problem of cheating by separately printed tests.

Second, we do not think it necessary or feasible in our exercises to explain what is wrong with each wrong answer, as Mr. Crowder does. His approach is appropriate for a highly integrated field, such as mathematics, contract bridge, or theology. We do not find it necessary in a looser field like English in which, if a student gets an item wrong, it is quite proper to say, "Too bad; better luck next time"—since the problem is bound to reappear in other forms and contexts. We are programming our material for about 80% success, so that, if we devoted a page to explaining why each wrong answer was wrong, about four out of five of these pages would be wasted. We find out by means of our tests which ideas gave trouble in each class, and then we use a teacher rather than the exercise to discuss these ideas further with the students who did not understand them. All of our exercises are back-stopped by a teacher; hence they do not have to be a self-contained system that can get along without a teacher.

Third, we do not think it necessary to convey information in our items by means of "cues" or "prompts" as Mr. Holland does, reflecting the

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views of Dr. Skinner. We present the information by means of a chapter in a book, a literary text, or a class discussion, and then make sure that every student understands it by asking him questions about it in our exercises. For example, item 1 of our first sample exercise asks, "About how old is the person addressed?" and provides four choices: six, eighteen, thirty, and fifty. It may be slightly unfair to Dr. Skinner but it illustrates our position to say that he would probably ask, "About how old is the 'child' mentioned in line 10?" He would insist that the student write in his own answer, rather than choosing an answer. Since the student has already been tipped off by the question that the person addressed is a 'child,' he would write in any number between three and ten, all of which we would have to accept as correct.

I simply do not want to ask questions in this way, and neither did the teachers who worked on our exercises last summer. In common talk we call them "leading questions," and in the jargon of testing we say that they contain "specific determiners." Dr. Skinner does not mind, since he wants at least 95% of his subjects to get the answer right, and he is quite happy if they all get it right. I may be unfair to him, but it seems to me that what he is after could properly be regarded as pure conditioned responses. I grant that the conditioned response may be the basis for all learning, but by the time students are approaching adulthood, it seems to me that the pure conditioned response is a long way down, and that what we have to manipulate are whole galaxies of conditioned responses.

This, however, is an issue that can only be settled by research, and we shall be glad to change if it turns out that Skinner's type of question produces better and faster learning than our type of question. We have already been influenced by his views to the extent of programming our exercises for about 90% success rather than our normal test quota of about 60% success. But we still think that the information with which a student deals in an exercise can be presented more effectively in a preliminary discussion, or in the text that is to be analyzed, than by the form in which the questions are asked.

You will find other differences as you study our illustrative exercises, but, as the time is short, I should like to mention just two others that I think are important. First, our exercises show that they know what is going on in the subject-matter field. The exercise on the poem is obviously influenced by what is called "the new criticism" and adapts it to the high school level. The vocabulary exercise is based on the semantic doctrine

that context determines meaning, and the exercise on sentence patterns is a very simple adaptation of structural linguistics. Hence these exercises have a high degree of academic respectability, which might be lacking if they had been designed by a psychologist who was only bent on adapting principles of learning to traditional subject-matter that is now out of favor. We may get a psychologist to administer this program, but I hope that we shall continue to insist that the exercises be developed by people who are well-informed in the subject-matter area.

Lastly, we do not insist on having the exercises developed in our shop or under our supervision. True, nothing will be released by ETS for general use until we are reasonably sure that it will work in the classroom and will not have undesirable side-effects on very many people, but on our way to that goal we hope to get hundreds of good English teachers interested in producing exercises like these, trying them out in their own classes, and sending us their results. As I said earlier, eighty-eight English teachers will be trying out about 500 pages of exercises during the coming year, and we hope to have about 1,000 pages ready for more general use a year or two from now.

This technological revolution in education is closer than you may think. My own view, not necessarily shared by ETS, is that these self-correcting exercises and the short tests that accompany them may take over about a quarter of the textbook market within five years and possibly forty to fifty per cent of it within ten years. They will not, of course, be the products of any one publisher, but they will be as common as blackboards, textbooks, and recitations. I shall leave you with a question that worries some of us at ETS. When schools already know how well each student is doing in each basic subject by means of about three thousand items a year in programmed exercises and weekly tests, what will happen to the mainstay of our profession, the annual standardized test?

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Sample Exercises

SPRING AND FALL

Gerard Manley Hopkins

- Margaret, are you grieving
2 Over Goldengrove unleaving?
Leaves, like the things of man, you
4 With your fresh thoughts care for, can you?
Ah! as the heart grows older
6 It will come to such sights colder
By and by, nor spare a sigh
8 Though worlds of wanwood leafmeal lie;
And yet you *will* weep *and* know why.
10 Now no matter, child, the name:
Sorrow's springs are the same.
12 Nor mouth had, no nor mind, expressed
What heart heard of, ghost guessed:
14 It is the blight man was born for,
It is Margaret you mourn for.

Directions: With a sheet of paper, cover everything below the item on which you are working. Read the item, look back at the poem, and write the number of the best answer in the () at the end of the item. Then move the sheet of paper below the next item. The number in parentheses is the intended answer for the preceding item. If your answer was not the same, put a circle around this parenthesis. If you disagree and want to discuss the item, add a question mark or exclamation point.

1. About how old is the person addressed? 1- Six 2- Eighteen
3- Thirty 4- Fifty ()
- (1) 2. What is Goldengrove? 1- Some English flower, like goldenrod
2- A particular plant to which she had given this name 3- A patch of
woods in autumn 4- A person named Goldengrove ()
- (3) 3. In line 2 "unleaving" means 1- not leaving (i.e., staying)
2- failing to produce leaves 3- unfolding leaves from buds 4-
shedding leaves ()

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(1) 4. The *opposite* of "the things of man" in line 3 is 1- the things of woman 2- the things of children 3- the things of nature 4- the ideas of man ()

(3) 5. In line 3 "leaves" are 1- addressed by the question, "Can you?" 2- the subject of "care for" 3- the subject of "can you" 4- the object of "care for" ()

(4) 6. In line 7 "nor spare a sigh" means 1- not be sparing of sighs (i.e., give many of them) 2- not give so much as a sigh 3- not express sorrow openly 4- not permit anyone to sigh ()

(2) 7. In line 8 "worlds" means 1- large quantities 2- imaginary worlds 3- planets like our world 4- little worlds (round balls) formed by wanwood ()

(1) 8. Which of the following is most like "leafmeal" in line 8? 1- Oatmeal 2- Bone meal 3- Piecemeal 4- Last meal ()

(3) 9. Which do you think is the best reading, and which is the next-best reading, of line 9? 1- Although others may not weep, you will, for you are more sensitive 2- Yet you will weep in the future, because life will be harder for you then, and you will know what real grief is 3- Yet you will weep in the future, but about the reality rather than the shadow, and then you will know why you are weeping 4- But you go right on weeping, in spite of what I have just said, and you want to know why () ()

(4) (3) 10. Which is the best reading of line 10? 1- Now you are not weeping about anything serious but about a name 2- Now this knowledge means nothing to you 3- Never mind now what name we give to the cause of your sorrow 4- I forget your name, but it does not matter ()

(3) 11. Which is the best reading of line 11? 1- Sorrow attacks you now as it will later 2- The ultimate source of all sorrow is the same 3- The springtime of sorrow is the same as the later stages 4- The emotional springs that ease the shocks of life are always the same ()

(2) 12. Which is the best reading of line 12? 1- You could not put it in words or even conceive as an idea 2- You do not now have words or concepts to understand why you will weep in the future 3- And I never told you in words or even in thought why you will weep 4- Neither literature nor science can tell you why you are weeping ()

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- (1) 13. What is the "ghost" in line 13? 1- The ghost of an idea
2- A departed soul 3- Margaret's soul 4- The writer's soul ()
- (3) 14. What is "the blight man was born for" in line 14? 1- Evil in general 2- Unhappiness 3- Sin 4- Death ()
- (4) 15. How do we know the poet means this? 1- Because sin is the ultimate source of all unhappiness 2- Because her soul unconsciously took the death of the leaves as a sign that she, too, would die 3- Because the overwhelming force of evil in the world is what finally makes us weep 4- Because man is born for sorrow, and that sorrow springs from unhappiness ()
- (2) 16. In line 15 why is she mourning for Margaret? 1- Because all sorrow is self-centered 2- Because the departing leaves make her feel lonely 3- Because she must die 4- Because she is dying ()
- (3) 17. In the title "Spring" stands for 1- sorrow's springs 2- the spring of the year 3- the happiness of youth 4- Margaret's age ()
- (4) 18. In the title "Fall" stands for 1- old age 2- death 3- the last years of Margaret's life 4- the writer's age ()
- (2) Now re-study the items you answered incorrectly.

Test on SPRING AND FALL

Directions: Encircle "Yes" if the sentence is a reasonable interpretation of any part of the poem. Encircle "No" if it is not.

- Yes No 1. Margaret, are you sad because your lover has deserted you?
- Yes No 2. Can't you think of anything but men?
- Yes No 3. As you grow older, you will be less moved by sights like this.
- Yes No 4. You will not grieve, no matter how many leaves fall.
- Yes No 5. But now you keep on weeping and want to know why you weep.
- Yes No 6. You have to rake up the leaves that fall on your lawn.
- Yes No 7. If you do not know my name, it makes no difference.
- Yes No 8. The ultimate cause of all sorrow is the same.
- Yes No 9. You could not talk about it or even think of it.

SAMPLE EXERCISES

- Yes No 10. But your heart and soul caught the meaning of the falling leaves.
- Yes No 11. The leaves show that the cause of all sorrow is sin.
- Yes No 12. Man was born in the state of original sin.
- Yes No 13. You are weeping only for your own petty sorrows.
- Yes No 14. The falling leaves told your heart that you, too, must die.
- Yes No 15. In the title, "Fall" stands for "immortality."

Vocabulary in Context

Directions: With a piece of paper, cover everything below the sentence on which you are working. Mark each sentence R (right) if the word in capitals is used correctly or W (wrong) if it is used incorrectly. If you don't know, guess. Then move the cover down below the next sentence (or item). You will see at the left, in parentheses, how you should have marked the preceding sentence. Check your mark if it agrees with this key; encircle it if it does not. In the ninth answer space write the number of the word or phrase that is nearest in meaning to the italicized word. Then use this word in a sentence of your own.

I. ABASE

- ___1. We should not abase ourselves before our superiors.
- (R)___2. The Tower of Pisa was abased for centuries without falling over.
- (W)___3. Those who are haughty shall be abased.
- (R)___4. Since he would not carry out orders, he was abased in rank.
- (R)___5. He abased the post for his mailbox five feet in the ground.
- (W)___6. He abased the pot of oatmeal with a hammer.
- (W)___7. Abasement is the penalty for those who lord it over others.
- (R)___8. He left his suitcase in abasement.
- (W)___9. *abase*: 1- set up firmly 2- lower 3- slanting 4- bottom
5- attack
- (2)

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2. ABSTRUSE

- ___ 1. Nuclear physics is a very abstruse subject.
(R) ___ 2. His sermons were too abstruse for his poor parishioners to follow.
(R) ___ 3. He was the most abstruse specimen of humanity I have ever seen.
(W) ___ 4. Abstruse subjects are not appropriate for elementary schools.
(R) ___ 5. I do not think he was wicked; he was only abstruse.
(W) ___ 6. He had read only an abstruse, not the original article.
(W) ___ 7. His explanation of space-curvature was too abstruse for me to follow.
(R) ___ 8. He could explain an abstruse theory in very simple terms.
(R) ___ 9. *abstruse*: 1- mathematical 2- degenerate 3- shortened account 4- hard to understand 5- hard to believe
(4)

Test on Vocabulary in Context

(The test would be given after about twenty words had been studied in the fashion indicated above. It would devote only one sentence to each word, but each test would repeat a few words from previous exercises. No sentence that had been used in an exercise would ever be repeated in a test. The following represents a portion of one such test.)

Directions: Encircle R for right and W for wrong uses of the italicized words.

- R W 1. It is all right to be humble but not to *abase* oneself as deeply as that.
R W 2. I could never forgive him for *abstrusing* his little sister.
R W 3. His *accesion* to the throne was celebrated by his subjects.
R W 4. He was *adjudged* the winner by a wide margin.
R W 5. The *animates* of the prison disliked their food.
R W 6. His *apostasy* was removed by a surgeon.

SAMPLE EXERCISES

Sentence Patterns

Try to remember the following sentence patterns well enough to label the practice sentences with the number and letter of the pattern they follow.

Pattern 1A. The subject verbs. (Joe lies. Mary gossips. Men vote.)

1B. The subject verbs an object. (Joe tells the truth. The car hit a tree.)

Pattern 2A. The subject is verbed. (Joe was punished. His car was stolen.)

2B. The subject is verbed by something. (He was struck by lightning.)

Pattern 3. The subject is something. (Joe is a boy. Joe is crazy. Joe was fourteen last year. Joe will be captain next year.)

Directions: With a sheet of paper, cover everything below the sentence on which you are working. In the blank at the left of each sentence write the number and letter of the pattern it follows. Look at the sentences above as often as you like to see which pattern a sentence follows. When you move the paper below the next sentence, you will see at the left, in parentheses, how you should have marked the sentence before. Check your mark if it was right; put a circle around it if it was wrong.

Practice Sentences

- ___ 1. Yogi Berra is a catcher.
- (3) ___ 2. Yogi Berra caught a foul.
- (1B) ___ 3. Yogi Berra hit a home run.
- (1B) ___ 4. Whitey Ford pitches.
- (1A) ___ 5. The pitch was bunted.
- (2A) ___ 6. The fly was caught by Willie Mays.
- (2B) ___ 7. Aparicio is a good shortstop.
- (3) ___ 8. He was hit by a pitched ball.
- (2B) ___ 9. The side was retired in order.
- (2A) ___ 10. The Dodgers won the pennant.
- (1B)

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- ___ 11. The baby is adorable.
- (3) ___ 12. The baby is a boy.
- (3) ___ 13. The baby was stung by a bee.
- (2B) ___ 14. The baby was treated by a doctor.
- (2B) ___ 15. The baby cried.
- (1A) ___ 16. The baby drinks milk.
- (1B) ___ 17. The baby is eight months old.
- (3) ___ 18. The baby was kidnaped.
- (2A) ___ 19. The baby was found by the police.
- (2B) ___ 20. The baby likes toys.
- (1B)
- ___ 21. Mary is a nice girl.
- (3) ___ 22. Mary likes boys.
- (1B) ___ 23. Mary flirts.
- (1A) ___ 24. Mary is liked by everyone.
- (2B) ___ 25. Mary is in love.
- (3) ___ 26. Joe dates Mary.
- (1B) ___ 27. Joe took Mary to a party.
- (1B) ___ 28. Mary gave Joe a kiss.
- (1B) ___ 29. Joe was happy.
- (3) ___ 30. Now Mary loves someone else.
- (1B)

(The test would consist of different sentences to be marked like those above.)

Appendix

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